Volume 83 Number 6

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGraw-Hill Company, Inc.
JAMES H. McGRAW, *President*
JAMES H. McGRAW, JR., *Vice-Pres.-Treas.*

Chicago, June, 1925

G. A. VAN BRUNT, *Managing Editor*

Just a Word on the Side

About My New Boss and Your Job and Mine

FELLOWS, I want to let you in on a little secret before official word may come to you from some other source. I've got a new boss whom I have worked with so long that he is new only in an official sense. It's G. A. Van Brunt, who has been Managing Editor of INDUSTRIAL ENGINEER and has worked hand-in-glove with my old boss since the paper was started. Van does not know that I am writing this and so I can speak freely and sneak this page into this issue while he's not looking. He's such a modest cuss and such a fine fellow and knows his stuff so well that I want you to get to know him just as well as I do. He has worked with my old boss long enough to get the benefit of his 15 years of experience in editing engineering publications and with that as a background, we are going to continue to give you just the best paper we know how to make with your co-operation. As my old boss has often said, "INDUSTRIAL ENGINEER is your paper and you can make it fit your own needs if you will continue to give us from time to time the benefit of your suggestions for articles that you would like to have us publish, and offer comments on changes or improvements that will help you in your work."

As to my old boss, D. H. Braymer, he has not left us completely but has simply transferred himself to a related line of work. We will still have his affection and a part of his time in an advisory capacity, and I feel sure that from now on you will see his name in the paper frequently in connection with discussions that he knows best how to write on the new work he will do. In brief, as I understand his plans, he will organize an engineering staff of specialists who will devote their time to the installation of power applications in industrial plants, buildings and power plants in the states of Iowa, Nebraska and the cities of St. Joseph and Kansas City. His office and headquarters will be in Omaha, Neb., and if you want to write him from now on simply address your letters to 727 Woodmen of the World Building, Omaha, Neb.

He takes with him our best wishes and I am sure he will have yours, too. On his part, he has authorized me to say that the time he has spent in working with you on your problems has created an affectionate regard for you as men and as doers of things worth while. I know that his feeling in this connection is genuine, for I have frequently heard him say that INDUSTRIAL ENGINEER readers have just the kind of brains and hands with which he likes to work. A better tribute none of us who are practical men could ask from another who has been one of us in spirit and action for a period of 15 years.

Practical Pete

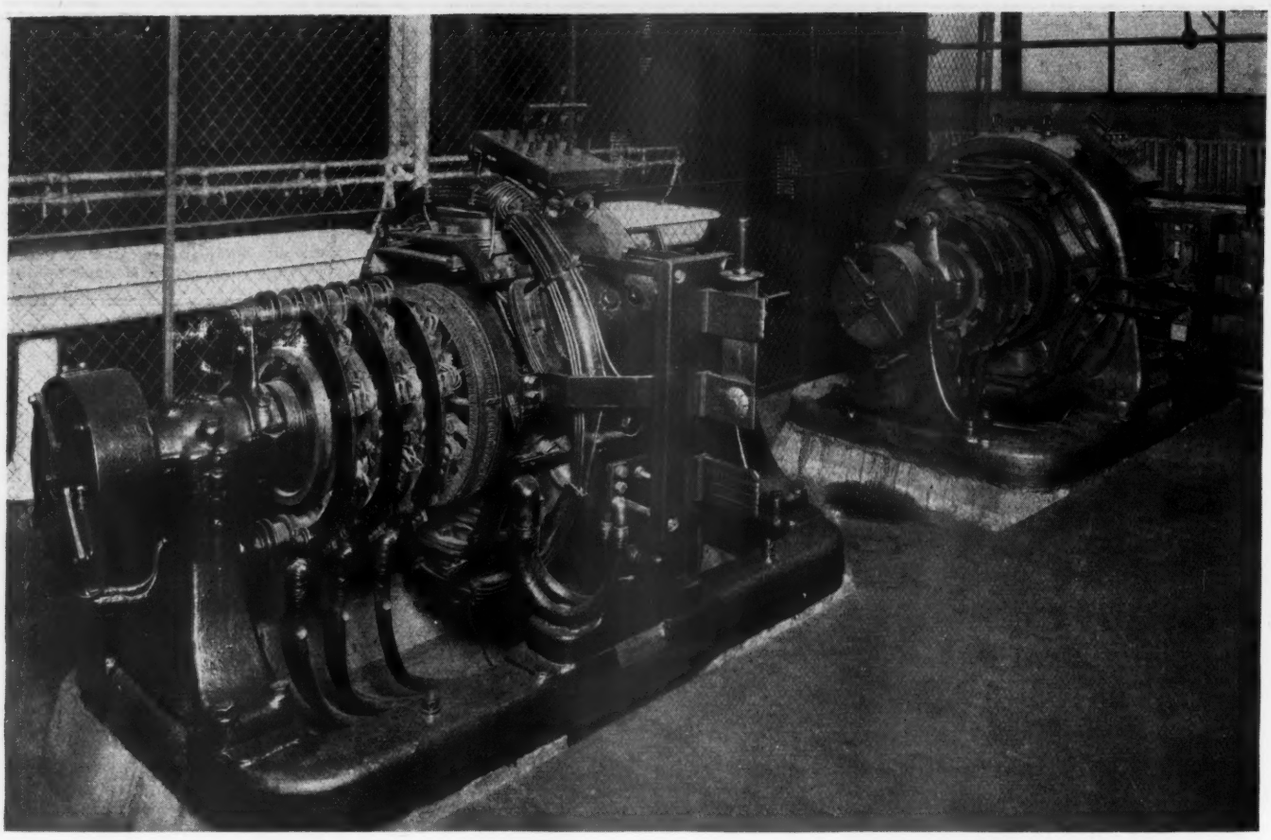


Fig. 1—The rotary converter shown at the left is a spare and is normally operated only in case the other one fails.

By floating it on the line as a synchronous condenser with over-excited shunt field, as is described in this article, a surprising amount of power factor correction was obtained. During periods of very light load, considerable corrective leading current was obtained from the other rotary. The machines are rated at 200 kw. and run at 1,200 r.p.m.

How Power Factor Was Improved by

Using Rotary Converter as Synchronous Condenser

Or as a Rotary Operating at Low Power Factor and Carrying a Small Load, Together With Graphs Showing the Amount of Corrective Current That May Be Obtained by Either Method

By ROBERT W. DRAKE

Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill.

SOMETIMES rotary converters must be operated for considerable periods at loads far below rating. In industrial plants these light-load conditions are frequently coincident with correspondingly light loads on the other electrical power equipment. If there is much induction motor load, such a light-load condition means a low average power factor of the total load. Under such conditions any corrective leading current which may be furnished by the under-loaded rotary or rotaries will be very welcome.

I was lately confronted with the following problem: For a special purpose of great importance in an industrial plant, a rotary converter had been installed. To assure the necessary reliability of service, a second converter had been installed for use in case of breakdown. Of course, this second machine was very seldom required. Under certain circumstances, the load on the converter in service was very light for days at a time. Leading current for power factor correction of induction motor load would be most useful. Just how much leading current could safely be taken from the lightly-loaded converter? Could the spare converter, operated as an over-excited synchronous motor without direct-current load, deliver a leading corrective current in worth-while quantity, without abnormal heating of the tap coils? If so, how much?

It is a well-known fact, that the heating of the individual coils in a rotary converter armature is unequal. The tap coils operate under the most unfavorable conditions and run the hottest. The relative heating of all coils varies with the power factor at which the converter is operated. Under all power factor conditions, however, the tap coils are hotter than any others and with the same kilowatt load on the converter the lower the power factor, the hotter are the tap coils.

Various discussions of this matter have been published from time

to time. One of the clearest and most useful of these discussions was contributed by Nicholas Stahl to the *Electric Journal* in 1912. Mr. Stahl published a set of curves similar to those in Fig. 2. These curves show that the kilowatt load which can be carried on a given rotary converter decreases very rapidly indeed with comparatively small departures from unity power factor. When a converter must carry continuous kilowatt loads approaching continuous rating, or short-time kilowatt loads approaching the corresponding short-time rating, it is evident that there is no safe alternative but to operate quite close to unity power factor.

Unfortunately the performance of rotary converters with very light load under very low leading power factor conditions was not included in Mr. Stahl's article nor in any published discussion of the subject that was available at the time. Since the work on which this article is based was completed, an article on this subject has been published by C. W. Bates in *Electrical World*.

Inasmuch as I was unable to find the answers to the questions raised in preceding paragraphs of this article, I decided to investigate the subject myself. The first step was to compute the curves shown in Fig. 3. These curves are similar to the curves shown in Fig. 2 except that they are carried to lower power factors. The agreement between my curves and the previous curves is very close at high power factors. The discrepancy of about 5 per cent at lower power factors is probably due to the fact that Mr. Stahl's curves are based on a converter having three or four armature coils per pair of poles, while my curves are based on a rotary having very many coils per pair of poles. This assumption was made because it greatly simplified the computations without introducing any considerable error. The discrepancy is small and my curves err on the side of safety.

Effect of Leading Power Factor Current at Light Loads

At first glance, Fig. 3 would seem to indicate that it is unsafe to operate even a lightly-loaded rotary at any appreciable load. Second thought suggests, however, that the small kilowatt loads allowable at low power factors represent considerable a.c. ampere loads. That is, even at very low power factors a fairly heavy wattless corrective current is allowable without causing tap coil heating above normal. It is evident that under the conditions outlined above, the point of controlling interest is the *a.c. ampere load* that can be carried, and not the kilowatt load. To bring out clearly the possibilities in this respect, the curves shown in Fig. 4 were plotted. These bring the matter out in its true light. Evidently a rotary will carry safely a surprisingly large wattless corrective current if the kilowatt load is low at all times.

THAT A ROTARY converter should be operated at very close to unity power factor is certainly true at full load. Mr. Drake, shows, however, that at light load a comparatively large amount of leading wattless corrective current can be taken from standard rotaries without exceeding their normal temperature rating. In this article he presents curves which show just what percentage of rated kilowatts and what percentage of rated alternating-current amperes any two, three, or six-phase rotary converter will carry at any power factor from unity to zero without exceeding normal continuous heating guarantees as to tap coil or armature heating. This factor varies to only a very slight extent with design and these curves are universal in application.

Where a duplicate or spare rotary is installed to assure continuity of operation, it is very seldom operated. In systems where wattless corrective current is desired to improve the power factor, such a machine may often be operated to excellent advantage as a synchronous condenser and may, without exceeding normal heating, be operated at an astonishingly high percentage of rated alternating-current ampere capacity. In this article Mr. Drake gives the details of operating a rotary in this manner.

When it is possible to operate a spare rotary for power factor correction purposes alone, without taking any direct-current load out of it at all, the machine is really a synchronous motor, not a rotary. The heating of the armature coils is no longer unequal, for the inequality of heating is a result of the "mixture" of alternating current and direct current in the winding of the rotary. With no direct-current load there is no direct current to "mix."

Under these circumstances the tap coils are no hotter than any others, and conditions would appear to be much more favorable for a heavy leading corrective current. A thorn lies in the following fact:

Under ordinary operating conditions the heating of rotary converter armature coils is so unequal that the controlling feature in design is not the *average heating*, but the heating of the hottest coils, the tap coils. With very light loads at low power factors, this inequality of heating becomes less and less. The relative heating of the tap coils decreases but the heating of the coils between taps becomes relatively greater. Finally we reach a point where the tap coil heating is no longer the controlling feature; the average heating of the whole armature is the controlling feature. This average heating is represented by the left-hand dotted part of the curves in Fig. 4. These curves enable an operating engineer to set a limit to the alternating-current amperes which can safely be allowed on any converter at low power factors, as limited by armature heating.

Shunt Fields May Limit Power Factor Correction Obtainable

There is another factor which must be considered, however, and that is the field strength and field heating. The design of the field windings of rotary converters varies through so wide a range that it is unsafe to attempt any general statement as to what is possible.

Most rotary converters of standard design have field windings designed to allow compounding of the converters by means of reactance on the alternating-current side. In some cases the transformers serving the converters are designed with high inherent reactance; in other cases, additional external reactance is necessary. Converters can be designed for any given amount of compounding by the use of a comparatively low value of reactance and a strong series field or by means of a high value of reactance and moderate series field. Both methods have been used. The shunt field design will vary with the relative strength of the series field. The series field will run cool enough on any converter operated within the allowable range of load for low power factor, but it is necessary to check up on the shunt field.

Probably the simplest method of doing this is to put one or more thermometers on those portions of the shunt field coils which are likely to be hottest—generally the surface about the center of the narrow space between coils. Use putty to obtain

good contact between thermometer bulb and coil, and cover the bulb well with putty. Then turn the shunt field rheostat until the resistance is all cut out, or until the alternating current delivered to the slip rings of the rotary reaches the maximum permissible value according to the curves shown in Fig. 4. It is generally the case with modern six-ring converters, operated at low power factor, that with all the shunt field rheostat cut out the slip ring current does not reach the allowable values according to the curves in Fig. 4. With the field rheostat adjusted to give the highest permissible current as per Fig. 4, or as near to this value as obtainable, continue operation of the rotary until the field surface temperature as indicated by the thermometers reaches 50 deg. C. hotter than the room temperature. Then cut in a little resistance in the field rheostat, and watch the thermometers. By trial determine the highest field rheostat setting which can be used without exceeding the 50 deg. C. rise on the field, and without exceeding the alternating-current amperes shown in Fig. 4. Mark the corresponding position on the rheostat, or better, block the rheostat sweep arm so that it cannot pass this point.

In the case of the rotaries which I used, shown in Fig. 1, the maximum power factor correction was limited by the heating of the field coils rather than by the average heating of the armature. In other words, a leading power factor alternating current of a value equal to that given by the curves in Fig. 4 could not be carried because the shunt fields of the machine overheated. It was therefore necessary to carry a little less current and obtain slightly less power factor correction.

If a worth-while corrective current, not much below the maximum safe value, is attainable, it will generally be advisable to make the best of it. If the difference is great, it is possible to remedy matters by shimming the poles, thereby reducing the air gap. This will change the compounding characteristics of the machine and is advisable only in case the man proposing to make the change has had considerable experience in such matters and is certain that the amount of shimming proposed will not render the machine less suitable for normal operation under the conditions of his particular application.

All of the preceding curves and discussions have been based on armature heating not higher than normal guarantees for continuous operation. Most modern rotary converters are designed and sold for safe operation (usually 55 deg. C rise) with two hours' operation at 150 per cent load. With corresponding operating temperature such machines will carry correspondingly heavier low power factor loads for two hours only, provided they are designed with heavy enough shunt fields. That is, machines with 2-hr., 150 per cent load guarantees will carry for 2 hr. only, half again the kilowatts and alternating-current ampere loads given in Figs. 3 and 4, so far as armature heating is concerned. Ordinarily such short-time operation at very low power factor is not called for, but in some emergency it may be helpful. For example, in case of a breakdown of one generator in an industrial power house, all the leading corrective current available may be desired for reducing the ampere load on the remaining generators during the lighting peak.

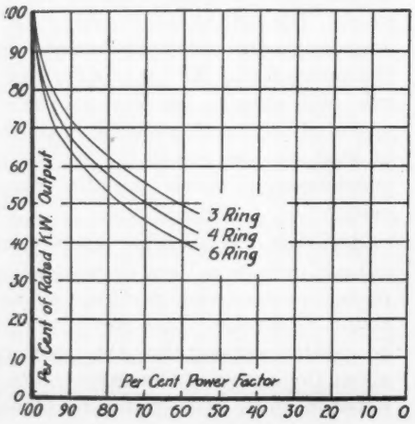


Fig. 2—The kilowatt load that can be carried by a rotary decreases rapidly with small departures from unity power factor.

For instance, a six-phase rotary converter operating at 90 per cent power factor can produce only 63 per cent of its rated kilowatt output without overheating the tap coils.

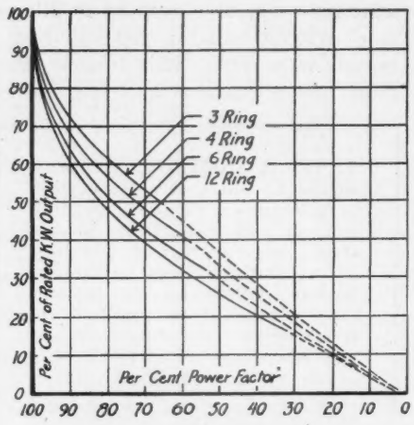


Fig. 3—Kilowatt output of rotary converters at low power factors.

These curves are similar to those in Fig. 2 except that they have been extended to include power factors down to zero. In the dotted portion of the curves the average heating of the armature, instead of the tap coil heating, governs the output. As can be seen very little kilowatt load can be carried by the rotary at low power factors.

How Commutation Trouble Was Eliminated

There is one other point which, although of controlling importance in comparatively few cases, deserves mention. The commutation of a rotary converter is decidedly poorer at low power factors. Full-load commutation at low power factors is often prohibitively bad, aside from all conditions of heating. However, with the conditions of operation outlined above, the amount of direct current to be commutated at low power factor is comparatively small. The machines which I used are modern, 60-cycle, compound-wound, six-phase rotaries with commutating poles. This commutation difficulty did not appear. Whether it would be a controlling feature with large machines without commutating poles I do not know.

In the case where a spare rotary is operated at zero power factor

(*Please turn to page 305*)

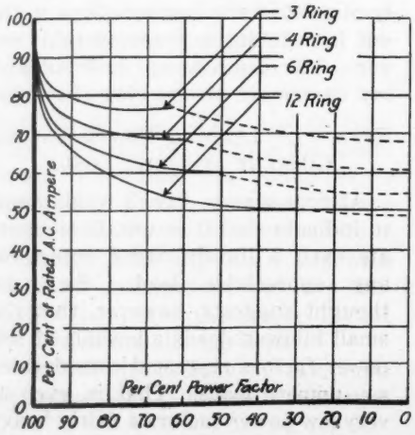


Fig. 4—Alternating-current ampere load of rotary converter at low power factors.

Although the kilowatt load that can be carried by a rotary when operated at low power factor is small, the alternating-current ampere load is not. For instance, a six-phase rotary will carry 54 per cent of its rated a. c. amperes at zero power factor and somewhat more at higher power factors. It was the relations shown in these curves that suggested that lightly-loaded rotaries could be used for power factor correction.

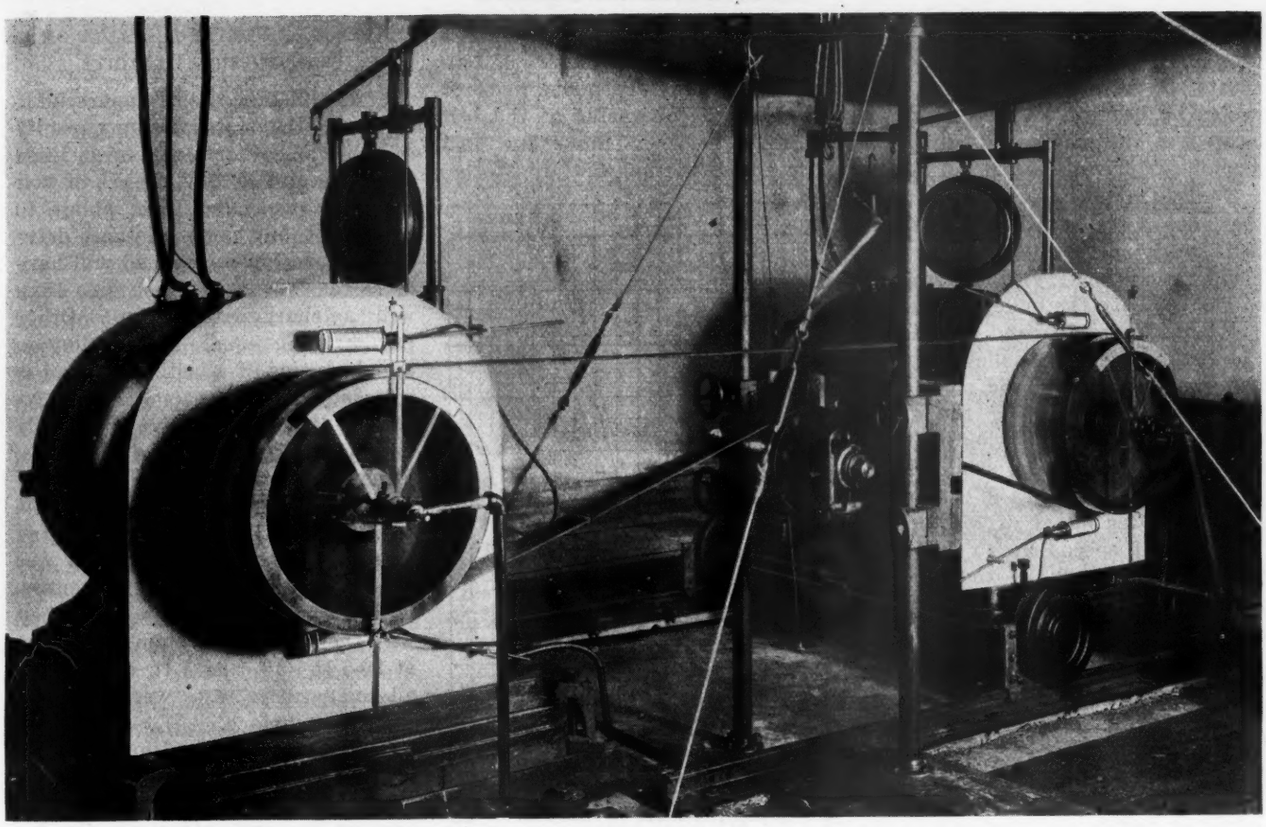


Fig. 1—This is the equipment used at Cornell University for testing belting under various conditions. It is designed so that the driving power required and the power delivered, as well as the revolutions per minute of both driver and driven pulleys, can be carefully measured.

Tests Which Show

How Service Conditions Affect Belt Capacity

Together With Tables and Charts That Will Enable Operating Men to Determine How Much Power a Belt Will Transmit, and Make Allowances Necessary in Laying Out a Drive

By R. F. JONES

Research Engineer, The Leather Belting Exchange Foundation, Cornell University, Ithaca, N. Y.

OPERATING MEN have long desired easily usable information that would enable them to lay out belt drives and make the proper allowances for the conditions which affect the power-transmitting capacity. As a part of the experimental work that has been carried on by The Leather Belting Exchange Foundation, at Cornell University, careful tests were made on horizontal belt drives to determine the effect of diameter and ratio of pulleys, center distance, high belt speed and the use of the gravity idler. The results of these tests are given here in the form of curves and tables that give the power which various weights of belt are able to transmit at different speeds, and the correction factors which indicate necessary allowances to be made for types of drive mentioned above.

MOST investigations made on the characteristics of belts in operation have taken into consideration only one set of factors or conditions affecting the power transmitted. However, belts in service seldom operate under such standard conditions as are determined by the tests. Also, most of these reports have been directed more toward the trained belting engineer than to the practical shop man in laying out belting installations under the miscellaneous service conditions found in practice.

In some recent experiments carried on at Cornell University, Ithaca, N. Y., under the auspices of The Leather Belting Exchange Foundation, the principal objective was to test belts under several standard conditions and, if possible, determine the laws under which they operated through the changes of conditions. This information was charted and a series of constants determined which are to be used as correction factors in the determination of the proper size of belt to use under different operating conditions. These tables and charts will be given and their use described later in this article.

Belt drives ordinarily fall into the two general classifications of horizontal or inclined belt drives, according to whether a line through the centers of the two pulleys is horizontal or inclined. In this determination, the study was made with horizontal drives only, under condi-

NOTE: Curves, tables and other information in this article are taken from a report made by The Leather Belting Exchange Foundation and copyrighted by The Leather Belting Exchange, Philadelphia, Pa.

tions approximately identical to those found in industry where line-shafts or countershafts are connected by belt, or where a motor is located at the side of the shaft or machine it drives.

To determine the factors affecting the power-transmitting capacity, belts were operated under the following conditions: Varying the arc of contact with the pulley diameters constant; increasing and decreasing the distance between pulley centers; operation with large and small pulley diameters; studying the effect upon the belt capacity when using a large pulley to drive a small pulley and *vice versa*, such as is commonly used on belted motor drives; operation at belt speeds up to 8,000 ft. per min.; a study of the gravity idler such as the Lenix, Pulmax or Belt-Slacker drives.

The first tests were made to determine the effect of the arc of contact or angle of belt wrap, which is considered as the angle measured in degrees from the point where the belt comes on the pulley to the point where it leaves.

If the driver and driven pulleys are the same size the arc of contact on each pulley will be approximately 180 deg., or one-half the circumference. Should one pulley be larger than the other, the smaller one will have a wrap less than one-half the circumference, and the larger one will have greater wrap than this. Theoretically the arc of contact has an important bearing on the transmission capacity of belting; so the first step was to set up apparatus to control the arc of contact while measuring the horsepower transmitted by the belt. Fig. 1 shows how the testing apparatus was adapted to this experiment. The idler midway between the pulleys may be moved vertically, so as to hold either side of the belt up or down, to give an arc of contact ranging from 140 to 210 deg.

Numerous tests showed that the arc of contact did materially affect a belt's capacity. However, later tests on small and large pulleys approached ordinary operating conditions more closely and gave more practical data on this subject; so none of the arc of contact material will be included. These tests served to give a clearer understanding of the practical problems involved, and were of material help in later work on the effect of pulley size and pulley ratio.

This work proved that the effect on the horsepower of the arc of contact change was dependent more or less upon the character of the belt surface. Another important fact discovered was that the arc of contact, as computed for a drive by ordinary geometrical methods, does not check that obtained on the running drive. The difference between the actual angle of wrap and the computed angle depends on the belt speed, thickness, tension, pulley size, center distance, whether the tight side is above or below and whether the drive is horizontal or vertical. An easier way of taking care of the factors introduced by the use of pulleys of different sizes, which is based entirely upon experimental results, is given later in this article.

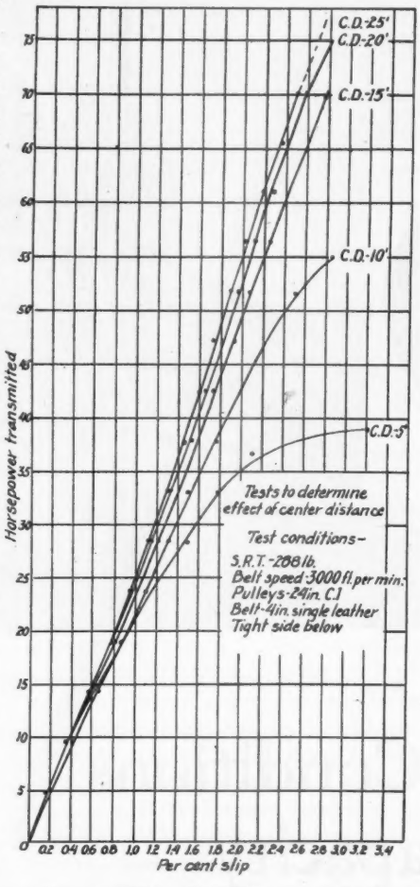

C.D.-25'
C.D.-20'
C.D.-15'
C.D.-10'
C.D.-5'
Tests to determine effect of center distance
Test conditions—
S.R.T.-288 lb.
Belt speed 3000 ft per min.
Pulleys-24in. C.I.
Belt-4in. single leather
Tight side below
Horsepower transmitted
Per cent slip
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
02 04 06 08 10 12 14 16 18 20 22 24 26 28 30 32 34

Fig. 2—The inability of short-center drives to carry heavy loads is well shown by these charts.

These tests show that a short-center drive operating under severe conditions can carry only about one-half the load of a long-center drive of the same pulley ratios. This is indicated by the curve showing the operation of a belt on a 5-ft. center distance, compared to the operation at 20- and 25-ft. center distances under a high percentage of slip. How the effect of short center distance is overcome is explained in the text, and the allowance which must be made for it is given in the tables.

Effect of Center Distance on Transmission Capacity

Center distance has an appreciable effect on the transmission capacity of a belt on a horizontal or inclined drive, because of the weight of belt material suspended from pulley to pulley. A long center distance drive when operating under load will have more tension on its slack side than will a short-center drive. Other things being equal, the tension on the slack side of a belt under load is a measure of its capacity and, therefore, a long-center drive inherently has more capacity than a short one. Experiments were made to determine how much power a belt would transmit at center distances ranging from 5 to 25 ft. The first test was made with the belt at 25-ft. centers, with the tight side below. The belt was then cut to accommodate tests at 20-, 15-, 10- and 5-ft. centers; so all comparative tests were made on the same surface.

The results obtained are given in Fig. 2 which shows the horsepower of a high-capacity belt charted against the percentage of slip for the five center distances marked on the curve. At high rates of slip, 2.75 per cent, there is a large decrease in capacity with a decrease in center distance, especially below 15 ft.; at lower slips, from 1 to 1½ per cent, the effect of shortening the center distance is much less.

How Pulley Sizes and Ratios Affect Transmitting Capacity

The diameter of the pulley is a factor in determining the operating capacity that has often been neglected, because, theoretically, the pulley size should have no effect on the belt's capacity. However, practical operating men have long known that a large pulley would pull better than a small one. It is common practice to increase the size of pulleys on drives which are giving trouble; the effect is an increase in the power-transmitting capacity of the belt which is largely attributable to the increase in belt speed.

To find the effect of the change in size of the pulley alone the shaft speed was regulated to give a uniform belt speed of 2,000 ft. per min. for all sizes of pulleys used. Cast-iron pulleys ranging from 6 to 36 in. in diameter were employed, with the driver and driven pulleys the same size in each case.

Several belts were used and in each case the capacity became

greater as the diameter of the pulley was increased. At slips up to 2.5 per cent the 36-in. pulleys gave the highest horsepower transmission; the 24-in. came next, and so on down to the 6-in. pulley, as shown in Fig. 3. This proved that, in general, the capacity of a belt will be less on small pulleys than it is on large ones, with the greatest reduction on pulleys below 12 in. in diameter. This subject will be discussed again later and correction factors will be given to show the allowance to be made for pulley size in designing belt drives.

One of the most important phases of belt transmission is encountered in the driving of a large pulley by a much smaller one, or the opposite. Series of tests were made on six different belts to determine what transmitting capacity may be expected when pulleys of different diameters are used together. Each series consisted of five tests in which a 36-in. pulley was driven consecutively by pulleys 36 in., 24 in., 18 in., 12 in., and 6 in. in diameter. All pulleys were of cast iron. In some cases tests were made at 5-ft., with another series at 10-ft., pulley centers.

The shaft speed of the driver was regulated to give a belt speed of 2,000 ft. per min. with each pulley combination. In some instances the conditions were reversed, so that the large pulley was used as the driver, with the same results as before. Therefore, the conclusion was reached that for the same pulley sizes, the same belt capacity would obtain regardless of whether the small or the large one was driving.

Tests on a 6-in. paper pulley driving a 36-in. cast-iron pulley indicated that it transmitted about 25 per cent more power than the all cast-iron combination.

In addition to the above a series of tests was made using pulleys ranging from 4 in. to 24 in. to drive a 24-in. pulley. Up to 2 per cent slip, or within the range of low slippage, the belt transmits the highest power with the largest driver pulley and the power becomes less as the driver is reduced in size. The greatest reduction in power takes place after the driving pulley is reduced below 12 in. in diameter.

The trend of these results is shown by the set of curves in Fig. 4. Here the horsepower transmitted at 1½ per cent slip is plotted against the diameter of the smaller pulley so that one curve is given for each

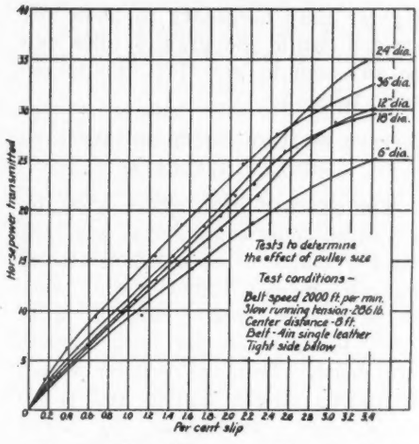


Fig. 3—The effect of pulley size is clearly shown by the results of these tests.

It is noticeable in these curves that the amount of horsepower loss increases rapidly as the diameters of the pulleys decrease. There would probably be a still greater increase of loss on pulleys below 6 in. in diameter. In this case the driving and driven pulleys are the same diameter. Extra small pulleys are not recommended for power transmission.

series of tests. The center distance and the type of belt are indicated. In each case the capacity of the belt decreases as the diameter of the smaller pulley is reduced. From this it is evident that a belt to be used on a cast-iron motor pulley of small diameter should be from 20 to 30 per cent wider than on a normal drive with large pulleys. If a paper motor pulley is used its increased capacity will tend to overcome the effect of the small pulley and not much allowance will have to be made except for motor pulleys below 6 in. in diameter, unless the driven pulley diameter is more than six times the diameter of the driver. Curves are

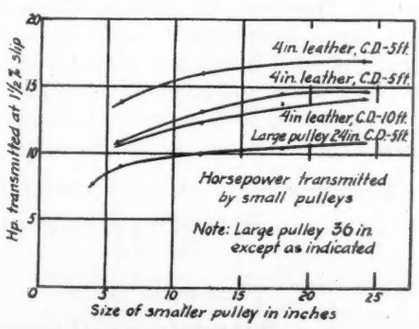

Hp. transmitted at 1½% slip
Size of smaller pulley in inches
4in. leather, C.D.-5ft.
4in. leather, C.D.-5ft.
4in leather, C.D.-10ft.
Large pulley 24in. C.D.-5ft.
Horsepower transmitted by small pulleys
Note: Large pulley 36 in. except as indicated

Fig. 4—This shows in another way the effect of the pulley size on the horsepower transmitted by a belt.

The rapid drop in the power transmitted where the driving pulley is below 12 in. is more clearly shown in this chart, which gives the results obtained by testing a belt under a uniform slip of 1½ per cent. This indicates that there should be some definite allowance made for small pulleys, such as are often attached to motors. The proper factors to compensate for this may be obtained either from Figs. 7 and 8 or Tables I and II.

given later in the report showing just how much to allow for cast-iron pulleys.

The work on different pulley combinations incidentally gave data on the position of the pitch line in a leather belt which is the point somewhere in the belt line that determines the working diameter of the pulley. It is common practice in figuring pulley sizes to add the thickness of the belt to the pulley diameters if a close calculation is required. This assumes that the pitch line is 50 per cent of the belt thickness out from the pulley face. Recent tests have proved that the pitch line is from 60 to 80 per cent of the belt thickness, with an average of 70 per cent out from the grain side of a single leather belt.

This is important in close speed calculations. For example, suppose a 36-in. pulley running at 200 r.p.m. is driving a machine with a 6-in. pulley through a single belt 0.2 in. thick. In computing the speed of the driven shaft, entirely neglecting the belt thickness, the method would be as follows:

$(36 \div 6) \times 200 = 1{,}200$ r.p.m. Assuming the pitch line of the belt to be out 50 per cent of the belt thickness, the belt thickness would be added to the pulley diameters and the computation would be:

$(36.2 \div 6.2) \times 200 = 1{,}168$ r. p. m. However, if the driven speed is figured on the assumption that the pitch line is 70 per cent of the belt thickness out from the pulley, 2 times 70 per cent of 0.2 in. would be added to the pulley diameters, or:

$(36.28 \div 6.28) \times 200 = 1{,}156$ r.p.m. which would be the maximum speed of this machine, neglecting slip entirely. A workman who does not understand these principles would expect to obtain 1,200 r.p.m. and would attribute the 44 r.p.m. difference to belt slippage. Even the difference between 1,168 r.p.m. as computed in the second case, and 1,156 r.p.m. might have an appreciable effect on production. Thus on drives where the driven machine speed must be closely regulated, the position of the pitch line has an important effect which should be taken into account in determining the exact pulley sizes or operating speed.

Operation of the Gravity Idler in Service

The gravity idler is a properly weighted idler, so pivoted from a long arm that the idler pulley runs

near the small pulley against the loose side of the belt, in such a way as to increase the arc of contact on this pulley to between 220 and 250 deg. At the same time the arc of contact of the larger pulley is increased to about 215 deg. These idlers are becoming more and more popular on difficult short center drives where there is a large difference in the diameters of the driver and driven pulleys. These idlers are commonly known under the names of Lenix, Pulmax or Belt-Slacker drives.

The same testing equipment, with the addition of a gravity idler, was used here. Belts were tested on short centers of approximately 5 ft. Weights were added to the idler to produce a tension sufficient to operate at about 1½ per cent slip; each belt required a different weight.

Tests were made at a belt speed of 2,000 ft. per min. on two different belts: first, without the idler, with the tight side on the bottom; and second, using the gravity idler for comparison. A good indication of the results is plotted against the percentage of slip for two of the comparative tests. Probably the most interesting feature of the results is the unusual shape of the gravity idler curve. Instead of curving to the right and indicating an increase in the rate of slip as the load becomes greater, the idler drive curve turns up and shows that the rate of slip increase is becoming less. This curve indicates that the idler drive has a much higher overload capacity than the normal drive but that it may slip more at light loads if used on a fluctuating load, unless extra weight is used on the idler.

The arc of contact is so much greater on both pulleys with the gravity idler drive that it permits the belt to carry the same load with less tension on the bearings. In these tests the bearing tension was from 10 to 27.5 per cent less with the idler drive for the same power transmission. In practice, the tension reduction would probably be more than this because the belt on a normal drive has to be set up tighter than necessary to allow for stretch, while the gravity idler can be adjusted to give just the necessary tension.

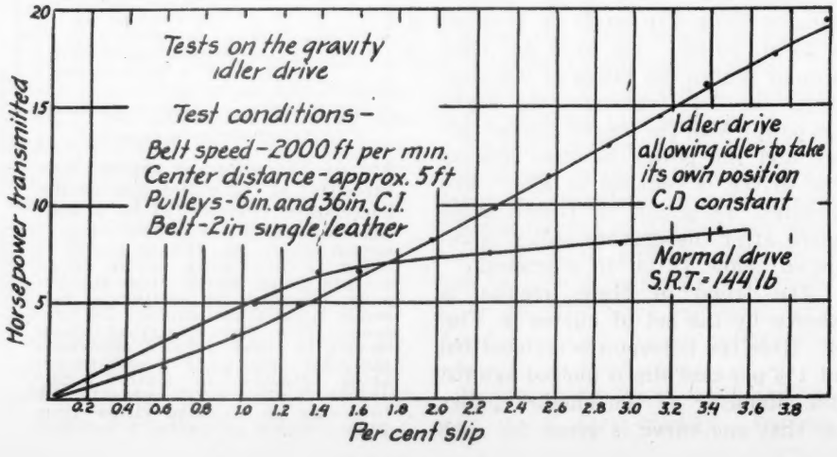

Tests on the gravity idler drive
Test conditions –
Belt speed – 2000 ft per min.
Center distance – approx. 5 ft
Pulleys – 6 in. and 36 in. C.I.
Belt – 2 in single leather
Idler drive allowing idler to take its own position
C.D constant
Normal drive
S.R.T. = 144 lb
Horsepower transmitted
Per cent slip
20
15
10
5
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8

Fig. 5—Some interesting results of the tests made on a gravity idler drive.

Here the same belt drive was tested with and without an idler drive. This could easily be done because the two parts of the testing machine may be separated sufficiently to give the proper tension. The idler drive is more effective under heavy loads, where it is needed, than when the loads are light.

Effect of High Speed on Capacity of Leather Belts

The effect of high speed, with the resulting centrifugal force, has long been a source of speculation among belting men. Experiments were made at belt speeds ranging from 2,000 to 8,000 ft. per min. on several belts. Tests were made which compared single, double and triple thicknesses, throughout the above speed range; in these cases the comparative tests were all made on the same belt surface. In order to do this a three-ply belt was made up and tested. The outside ply was then stripped off leaving a double belt with the same transmitting surface. When this was tested the operation was repeated, producing a single belt. In this way all comparative tests of single, double and three-ply thicknesses were much less subject to the factor which causes the greatest experimental error: namely, variations in belt surface.

Representative results are indicated in the chart, Fig. 6, which shows a series of tests comparing a 2-in. single and a 2-in. three-ply belt. Horsepower is plotted on the vertical axis against belt speed on the horizontal axis, at a slip of 1½ per cent.

On tests on a belt which had been buffed to give it a low transmission capacity the peak loads were reached at 6,500 ft. per min. and the power transmitted decreased from that point. However, the curves, which are for a high-capacity belt, show that the peak is reached somewhere between 7,000 and 8,000 ft. per min.

In addition to transmitting more power per inch of width, a high-capacity belt has its greatest power at a high speed. A high power peak is important in the operation of a high-speed belt, because such a belt has more capacity than ordinary belts at any speed and a great deal more at high speeds. The curves on this chart, Fig. 6, furnish a good comparison of the relative capacities of single and three-ply belts. The following conclusions were drawn from this test:

(1) The speed at which the maximum power, or power peak, of a leather belt occurs, depends upon the frictional condition of the leather. A belt with

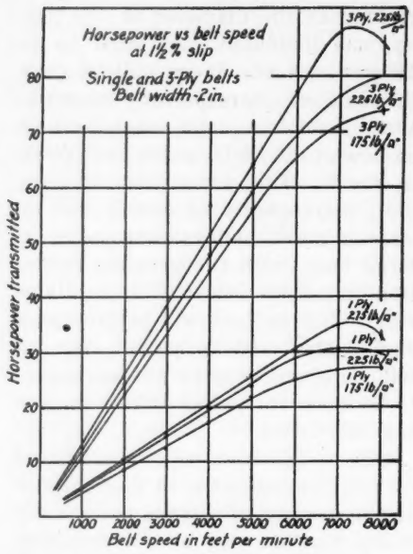


Fig. 6—These tests show that belts may be operated effectively up to between 7,000 and 8,000 ft. per min.

Other tests indicated that the power transmitted by belts with a poor surface began to drop at about 5,000 ft. per min. Also, these tests seem to indicate that the relation of capacity and speed for the various weights of belt follow definite laws. It must be remembered, however, that for high-speed operation it is necessary to have a cemented joint in the belt. These tests also show the possibility of transmitting power at speeds well beyond that at which the computed centrifugal force equals the initial testing. This value has usually been considered the absolute limit of transmission for all belts.

a poor surface shows a peak at about 5,000 ft. per min., while a good belt might go to a maximum of 8,000 ft. per min.

(2) Belt speed seems to have about the same effect on single, double and three-ply belts; so a constant relation between their capacities can be established for all speeds.

(3) It is possible to transmit power at speeds well beyond the speed where the computed centrifugal force equals the initial tension.

Rating Charts for Leather Belting Based on Experimental Data

The above paragraphs contain a brief resume of the research work necessary to secure enough information to allow properly for the effect of the various conditions of pulley size, center distance, and belt speed. The next problem is to put the information in such form that it can be readily applied by the average person to practical belt problems. To do this necessitates the use of two curve sheets. The first of these, Fig. 7, may be considered as a series of master curves from which the horsepower per inch of width is readily obtained for any belt speed up to 8,000 ft. per min. in all weights of belt up to three ply; a separate curve, however, is used for each weight of belt.

These curves are intended to apply to local conditions only; consequently the horsepower obtained from them should be corrected for the effect of center distance and pulley size. A second chart, Fig. 8, contains three correction curves for modification of the ideal ratings obtained from Fig. 7. Two of the curves on Fig. 8 are used to correct center distance with the tight side of the belt above or below, and the other is for pulley size. The vertical axis of the chart gives the correction factors for center distances between 4 and 25 ft., and for the smaller of the two pulleys when its diameter is between 4 and 36 in. The correction factors are multiplied together and the result multiplied by the horsepower obtained from Fig. 7 to give the corrected horsepower per inch of width.

These curves take care of the effect of the arc of contact, pulley size, pulley ratio, center distance, whether the tight side is above or below, and belt speed as is explained more fully in the caption accompanying the two charts, Figs. 7 and 8. These charts are not intended for use with vertical or quarter-turn drives, as no investigations have been made under such conditions.

Many persons find that tables are much easier to use than curves, and to give these data a wider range of usefulness they have been incorporated into the tables given herewith. Table I contains the horsepower ratings per inch of width for the different weights of belts, the values having been taken directly from the chart, Fig. 7. Table II gives the correction factors for center distance and pulley diameter, and in addition multiplies them together. It is necessary only to multiply the horsepower from Table I by the correction factor from Table II to obtain the correct horsepower per inch of width. The two columns under each center distance in Table II, one marked Above and the other Below, indicate the correction when the tight side of the belt is on top (above) or on the bottom (below)

Figs. 7 and 8—These curves are used in conjunction to obtain correction factors for determining allowances, because of center distance, pulley size and whether the tight or loose side of the belt is on top, when laying out a belting installation.

If preferred, Tables I and II may be used instead of reading the values from the curves. In the use of these charts the following precautions must be observed: (*a*) These charts are to be used only on horizontal or approximately horizontal drives. (*b*) Do not use Fig. 7, at left, without the corrections from Fig. 8, at right. (*c*) The diameter of the larger pulley should not be more than six times the diameter of the smaller one. To use these curves, with these three points in mind, proceed as follows:

(1) Find the correction for center distance from one of the two center-distance curves, depending on whether the tight side is above or below. If the center distance is greater than 25 ft., use the correction for 25 ft.

(2) Find the correction for pulley size from the pulley-size curve, Fig. 8, using the diameter of the smaller of the two pulleys. If both pulleys are larger than 36 in. in diameter no correction is necessary.

(3) Choose the curve, Fig. 7, at left, corresponding to the desired weight of belt, and take from it the horsepower per inch of width according to the belt speed used.

(4) Multiply the result of (*1*), (*2*) and (*3*) together to get the corrected horsepower per inch of width.

(5) Divide (*4*) into the total horsepower to be transmitted to get the correct width of the belt.

As an example, suppose a 10-in. pulley running at 1,000 r.p.m., giving a belt speed of 2,600 ft. per min., is to transmit 15 hp. to a 36-in. pulley at a center distance of 8 ft. Assuming the tight side is below, what size of heavy single belt is required? Carrying the computations through in the same sequence as indicated, the procedure is as follows:

(1) The correction factor for 8 ft. center distance with T_1 (the tight side) below is obtained from Fig. 8 and equals 0.87.

(2) Correction factor for 10-in. pulley size from Fig. 8=0.853.

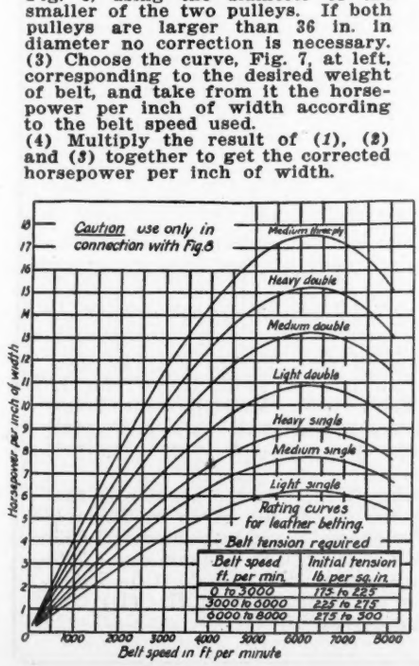
(3) Horsepower per in. width, from Fig. 7, at belt speed of 1,600 ft. per min. for heavy single belt=5.25.

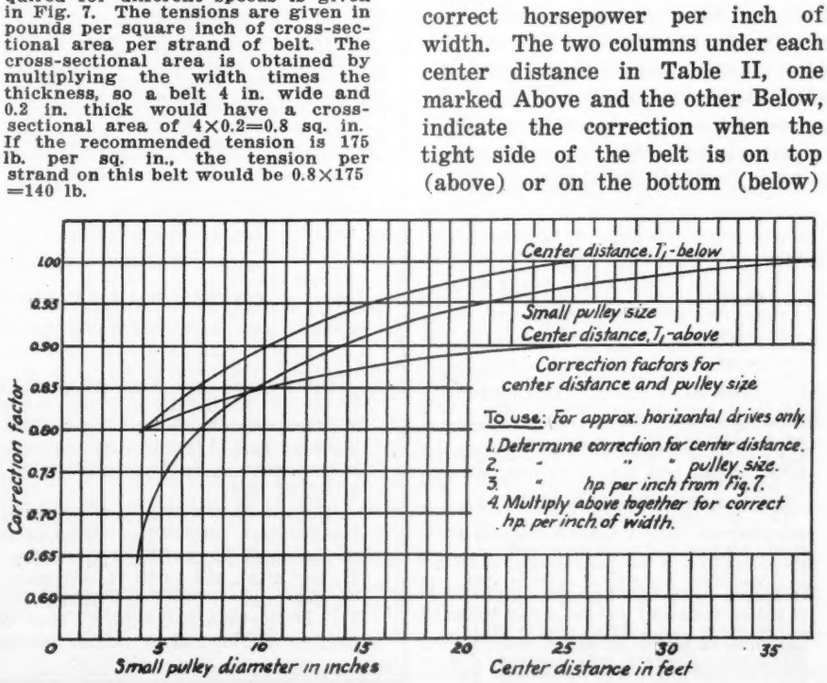
(4) Multiplying, $0.87 \times 0.835 \times 5.25 = 3.9$ horsepower.

(5) Divide 15 by 3.9=3.85, width of belt.

Therefore, use a 4-in. heavy single belt.

When the width of belt comes out an uneven size such as 3.85 in. the next larger size should always be chosen. A table of the initial tensions required for different speeds is given in Fig. 7. The tensions are given in pounds per square inch of cross-sectional area per strand of belt. The cross-sectional area is obtained by multiplying the width times the thickness, so a belt 4 in. wide and 0.2 in. thick would have a cross-sectional area of $4 \times 0.2 = 0.8$ sq. in. If the recommended tension is 175 lb. per sq. in., the tension per strand on this belt would be $0.8 \times 175 = 140$ lb.


Caution use only in connection with Fig. 8
Medium three-ply
Heavy double
Medium double
Light double
Heavy single
Medium single
Light single
Rating curves for leather belting.
Belt tension required
Belt speed ft. per min. | Initial tension lb. per sq. in.
0 to 3000 | 175 to 225
3000 to 6000 | 225 to 275
6000 to 8000 | 275 to 300
Horsepower per inch of width
Belt speed in ft per minute


Center distance, T_1 - below
Small pulley size
Center distance, T_1 - above
Correction factors for center distance and pulley size
To use: For approx. horizontal drives only.
1. Determine correction for center distance.
2. " " " pulley size.
3. " hp. per inch from Fig. 7.
4. Multiply above together for correct hp. per inch of width.
Correction factor
Small pulley diameter in inches
Center distance in feet

of the horizontal, or nearly horizontal, drive.

The biggest objection to the use of tables is that interpolation is necessary to determine quantities not given in the tables. Thus, in Table I, it was possible to give the horsepower only at intervals of 500 ft. per min.; so interpolation will often be required. In doing this, it is advisable to use the nearest 50 or 100 ft. per min. If the belt speed is below 500 ft. per min. it would be better to use the nearest 25 ft. per min. in order to reduce the percentage of error. The explanatory caption in connection with these Tables gives an example of each step of an easy method of interpolation for Table I.

Enough values are given in Table II for correction factors so that interpolation will seldom be necessary and, when it is, the correction can usually be estimated closely enough for all practical purposes. These tables are subject to the same limitations that are imposed on the curves in Figs. 7 and 8.

The following explanation of assumptions on which these curves are based may assist practical men in obtaining a more complete understanding of belts and belt operation. The set of curves in Fig. 7 are based on two principles. The first is, that the rate of slip in ft. per min. should increase with the belt speed, but that the percentage of slip should decrease. Therefore, a belt performing in accordance with this assumption should slip about 1.5 per cent up to 2,000 ft. per min., 1.25 per cent at 3,000 ft. per min., 1 per cent at 4,000 ft. per min., 0.9 per cent at 5,000 ft. per min., 0.8 per cent at 6,000 ft. per min. and 0.75 per cent at 7,000 to 8,000 ft. per min. The second principle is that speed affects the various thicknesses of leather belting in the same way, so that definite ratios between the capacity of the different thicknesses can be established which will hold true for all speeds. In terms of medium-single belt the following ratios were used: light single, 0.81; medium single, 1.00; heavy single, 1.15; light double, 1.40; medium double, 1.70; heavy double, 1.95; medium three-ply, 2.25. It is assumed that the initial tension should be applied in proportion to the belt thickness, as given in the government specifications for all weights of belts.

The center distance curves, Fig. 8, which are based on these experiments, are constructed so as to give proper center distance allowance for a belt of average capacity. There was not as much variation as this on a low-capacity belt, but considerably more on a high-capacity belt; so the curves are a compromise between the two. The effect of center distance with the tight side on top is

(*Please turn to page 305*)

Table I and II—Where desired, these tables may be used in determining rating of leather belting instead of Figs. 7 and 8.

Suppose, for example, that it is desired to find the horsepower for a medium single belt operating at 2,860 ft. per min. The procedure is as follows:
(1) Choose values of horsepower for nearest speeds, one higher and the other lower than the given speed. Example: If given speed=2,860 ft. per min., use 2,850 ft. per min. Horsepower at lower table speed, which is 2,500 ft. per. min.=4.35. Horsepower at higher table speed, which is 3,000 ft. per min.=5.15.
(2) Subtract lower table speed from given speed and divide by 500. Example:
2,850—2,500=350.
350÷500=0.7.
(3) Subtract lower table horsepower from higher table horsepower. Example: 5.15—4.35=0.80 hp.
(4) Multiply results of (2) by (3). Example: 0.7×0.80 hp.=0.56 hp.
(5) Add result of (4) to lower table horsepower for correct value of hp. per inch of width from Table I. Example: Correct horsepower for 2,850 ft. per min.=4.35+0.56=4.91 hp.

Table I—Horsepower Transmitted by Belts Per Inch of Width at Different Speeds

Weight of Belt	Belt Speed in Feet per Minute															
	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
Light Single....	0.75	1.45	2.16	2.87	3.53	4.15	4.70	5.20	5.60	5.95	6.20	6.30	6.30	6.15	5.85	5.45
Medium Single..	0.90	1.80	2.68	3.55	4.35	5.15	5.80	6.42	6.95	7.35	7.62	7.78	7.75	7.57	7.25	6.76
Heavy Single...	1.05	2.06	3.10	4.10	5.05	5.93	6.70	7.40	8.00	8.42	8.75	8.92	8.92	8.75	8.36	7.76
Light Double...	1.25	2.53	3.76	4.95	6.10	7.17	8.12	9.00	9.70	10.30	10.70	10.92	10.90	10.65	10.16	9.48
Medium Double	1.52	3.08	4.60	6.00	7.40	8.70	9.90	10.95	11.82	12.50	13.00	13.22	13.20	12.90	12.35	11.55
Heavy Double..	1.77	3.55	5.30	6.95	8.55	10.05	11.45	12.60	13.60	14.35	14.92	15.22	15.20	14.85	14.20	13.20
Medium Triple..	2.05	4.10	6.10	8.05	9.88	11.60	13.15	14.50	15.62	16.52	17.20	17.55	17.5	17.10	16.40	15.30

Table II—Correction Factors Which Compensate for Center Distance and Pulley Diameter

Dia. of Smaller Pulley Inches	Center Distance in Feet															
	4		6		8		10		12		15		20		25	
	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below
4	0.53	0.53	0.54	0.55	0.55	0.57	0.56	0.59	0.57	0.61	0.58	0.63	0.59	0.65	0.59	0.66
5	0.59	0.59	0.60	0.62	0.62	0.64	0.63	0.66	0.63	0.68	0.65	0.70	0.66	0.72	0.66	0.74
6	0.62	0.62	0.63	0.65	0.65	0.68	0.66	0.70	0.67	0.72	0.68	0 74	0.69	0.76	0.70	0.78
8	0.66	0.66	0.67	0.69	0.69	0.72	0.70	0.74	0.71	0.76	0.72	0.78	0.73	0.80	0.74	0.82
10	0.68	0.68	0.70	0.71	0.71	0.74	0.73	0.77	0.73	0.79	0.75	0.81	0.76	0.83	0.77	0.85
12	0.70	0.70	0.72	0.74	0.73	0.77	0.75	0.79	0.76	0.81	0.77	0.83	0.78	0.86	0.79	0.88
15	0.73	0.73	0.74	0.76	0.76	0.79	0.77	0.82	0.78	0.84	0.80	0.86	0.81	0.89	0.82	0.91
18	0.75	0.75	0.76	0.78	0.78	0.81	0.79	0.84	0.80	0.86	0.82	0.89	0.83	0.91	0.84	0.93
24	0.77	0.77	0.79	0.81	0.81	0.84	0.82	0.87	0.83	0.89	0.85	0.92	0.86	0.94	0.87	0.96
30	0.79	0.79	0.81	0.82	0.82	0.86	0.84	0.89	0.85	0.91	0.87	0.94	0.88	0.96	0.89	0.98
36	0.80	0.80	0.82	0.84	0.83	0.87	0.85	0.90	0.86	0.92	0.88	0.95	0.89	0.98	0.90	1.00

Directions for Use of Horsepower Rating Tables for Leather Belting—1. Determine horsepower per inch of width from Table I. 2. Determine correction factor from Table II. 3. Multiply values from Tables I and II together for correct horsepower per inch. 4. Divide total horsepower to be transmitted by horsepower per inch to get required width of belt.

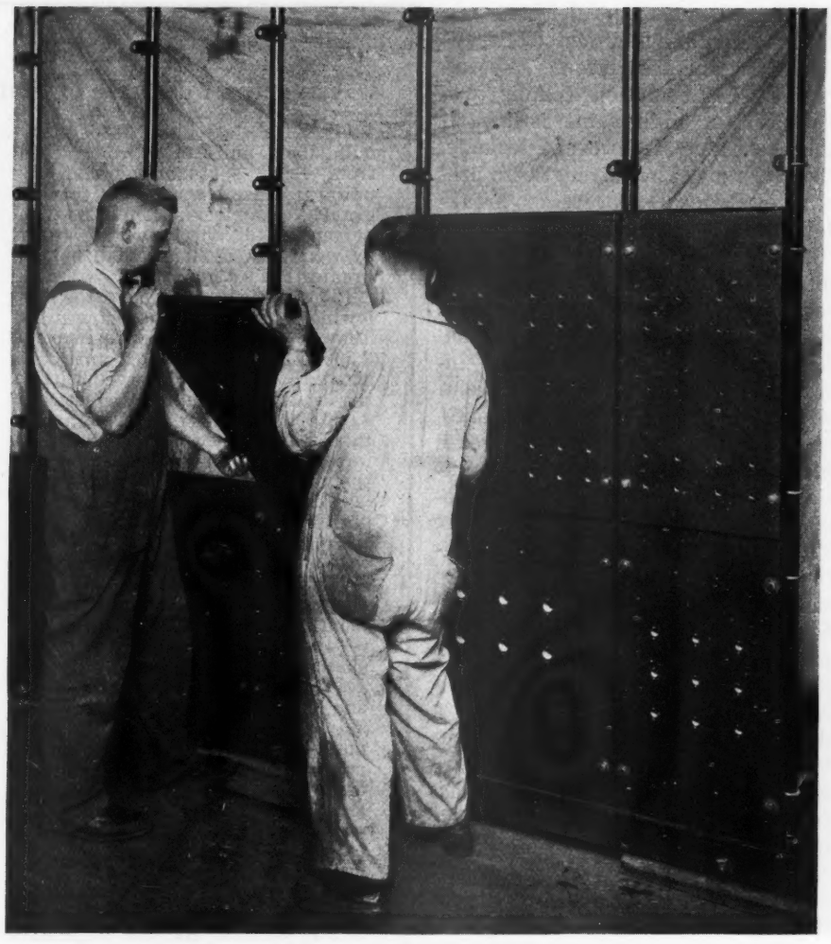
Note—(A) Above and below in Table II refer to the position of the tight side. (B) When interpolating for speeds not given in Table I use nearest 50 or 100 ft. per min. For example: If belt speed is 1,665 ft. per min., use 1,650 ft. per min., or if it is 1,690 ft. per min. use 1,700 ft. per min. (C) If the center distance is over 25 ft. use 25 ft. in Table II. If the smaller pulley is over 36 in. use 36 in. in Table II. (D) Use only on horizontal or nearly horizontal drives.

SWITCHBOARDS are the nerve-centers of electrical distributing systems and as such have to perform a number of important functions. The proper discharge of these functions and the maintenance of continuity of service to the electrically-driven equipment depend to a large extent upon the materials of which the switchboard is constructed and the manner in which these materials are assembled. In this article, Mr. Notvest outlines the essential characteristics which should be possessed by materials suitable for use in switchboards and discusses the use of slate for this purpose. Also, he gives helpful suggestions on how to select and handle slate.

Practical Pointers on the Use of

Slate as a Switchboard Material

With Specifications for Its Purchase and Suggestions on How to Install It So as to Secure the Best Service Therefrom



Properly locating the holes for the bolts will do much to facilitate the assembly and alignment of the slate panels on a switchboard. This illustration shows the proper method of putting the panels in place. Care must be taken to see that the bottom panels rest on a substantial base and that the upper panels rest on those below them, so that their weight is not supported by the holding bolts.

By ROBERT NOTVEST

Consulting Engineer, The Structural Slate Company, Pen Argyl, Pa.

FOR a clear understanding of the basic requirements which any given switchboard material must meet in order to secure the uninterrupted distribution of electrical energy, it may not be amiss to define the functions of such equipment as switchboards, panelboards, and industrial control equipment on which slate and similar materials are employed for the permanent mounting of the component devices.

Switchboards and panelboards are the assembly of such devices as switches, circuit breakers, rheostats, oil switches, contactors and relays, which permit, either through manual or automatic operation, the distribution of electrical energy. In addition, they combine with the means of connecting and disconnecting circuits, the necessary instruments for measuring the quantity of electrical energy distributed to the various circuits, and for protecting automatically, through relays, fuses, circuit breakers, oil switches, resistances and reactances, the generating station from the destructive effects of overloads, short-circuits, grounds and various other troubles and conditions which may arise and cause serious damage not only to the generating machinery and the distribution system, but also to the equipment which uses electrical power. While switchboards and panelboards have the function of protecting and regulating the distribution of electrical energy as such, industrial control apparatus can be defined as switching and protective gear used in connection with an electric motor, forming an essential part thereof to secure the proper performance required of the motor.

Characteristics Which a Switchboard Material Must Possess

It may be interesting to consider for a moment some of the essential characteristics which any material used for the construction of switchboards and panelboards, for mounting industrial control equipment and so on, should possess, so that industrial plant men who are called upon to select or build such equipment may go about their task more intelligently.

(1) Switchboard material must be a good insulator; that is, a substance which will in greater or less degree confine the electric current and force it to traverse a predetermined path. We must define the term electric insulation as embracing in its meaning three important functions which must be fulfilled before any material can be utilized for safely and permanently confining electrical energy. These functions are: (1) Dielectric constant, or specific inductive capacity. This should not vary excessively under changes of temperature or potential. Although this quality is, for many insulating materials, fairly constant under direct-current potentials, under alternating-current pressures it becomes erratic and is greatly affected by changes in temperature or frequency. In the case of composite dielectrics it is also affected by the inherent characteris-

tics of each component dielectric and its individual peculiar factor of transient capacity absorption. (2) Resistivity or insulation (ohmic) resistance. A high value is invariably desirable, to prevent leakage. (3) High dielectric strength, to prevent mechanical rupture or breakdown under high potential stresses.

A high degree of purity of the insulating material is another prerequisite, as even under constant electrostatic pressure minute impurities may cause a considerable increase in the flow of leakage current. High porosity of an insulating material may not only greatly decrease insulation resistance, through an initial content of moisture, but also produce this condition by reabsorption. The surface resistance of an insulator is, in turn, greatly influenced by the finish of the material and the humidity of the atmosphere at the place of installation. Experimental data so far obtained seem to indicate that failure or rupture in a dielectric is of a progressive nature; that is, the final disruptive failure is preceded by a continually increasing conductivity due to cumulative overheating.

(2) The material must possess sufficient strength to bear, without danger of breaking or bending, the weight of heavy instruments, switches, circuit breakers, and so on. The compressive strength must likewise be high. The importance of this is seen from the fact that panels in general are screwed or bolted tightly against four or six irregular points of contact on the angle-iron or pipe frame. In the vast majority of cases the contact surfaces do not correspond to a true plane and distortional stresses are set up when the panel has to be forced to conform to the irregularities of the framework. Furthermore, circuit breakers and switch studs, especially in the large sizes, are tightened down very hard. Great compressive stresses are also caused by the leverage of oil switches, motor starters, rheostats and heavy instruments when mounted directly on the panel.

Recommended Specifications Covering Purchase of Slate for Electrical Purposes

(1) Such slate shall be of clear mill stock, uniform in color, free from veins, spots and cracks, of uniform dense texture with specific gravity of approximately 2.8. The percentage of absorption of water by weight in 24 hours shall not be greater than 0.3 per cent.

(2) All slate shall have the following physical characteristics: Tensile strength, approximately 3,500 lb. per sq. in. Compressive strength, not less than 10,000 lb. per sq. in. Modulus of elasticity, 8,000,000 lb. per sq. in. Toughness, that is, resistance to fracture under impact, shall be determined under the method advocated by the American Society for Testing Materials, and show a factor of not less than 12.

(3) All slate shall be easy to drill and shall not be used for electrical purposes until three months from date of quarrying.

(4) The face, and edges of panels shall have even, true surfaces, accurately cut to dimensions given and shall not vary more than $\frac{1}{8}$ in. Any adjoining edges or sides shall not deviate from a right angle by more than $\frac{1}{32}$ in. Bevels shall be cut true entirely around panels and shall be measured by the projected width and depth. The back of the panels shall be free from lumps or depressions, but need not be trued.

(5) All slate shall be tested prior to shipment with 2,200 volts alternating current and the impedance leakage actually measured by means of either a wattmeter in the primary of the transformer used, or by the voltmeter method of determining the voltage drop in a transformer of given capacity, or with a milli-ammeter in series with the high-tension circuit. The impedance leakage shall not exceed such limit in milli-amperes as may be determined to be expedient for the particular application.

(6) Holes drilled in the slate for the purpose of securing it to the supporting angle irons or pipe framework shall be from 15 per cent to 20 per cent larger in diameter than the screws, bolts, capscrews or studs used for this purpose. Also, between the surface of the slate and the points of contact on the supporting framework there shall be interposed compressible washers of suitable size of such material as rubber, leather, felt, fibre, etc., to compensate for the irregularities of the surface of the framework.

(7) Slate slabs over 4 sq. ft. in area, mounted on framework shall rest on an angle-iron support, so that whenever possible the fastening bolts, screws or studs do not carry the weight of the slate, but only hold the same in place. In the case of large switchboard assemblies, all panels shall rest on a substantial channel-iron base, preferably cushioned with a strip of the above-mentioned compressible material between the slate and the base.

(3) The material must possess a certain amount of elasticity. Switchboards by necessity have to be installed in such locations that they are constantly subjected to vibration and jars from the equipment which they control. In the field of industrial control apparatus such applications as protective panels for cranes, hoists or elevators, automatic motor starters on machine tool service, and so on, are instances where the switchboard material is subjected to shocks and severe vibrations and must have a high factor of elasticity.

(4) Sufficient toughness to withstand the service conditions to which it is subjected, is essential. The general tendency of industrial plants to use motor drives, has opened up a wide field for automatic motor starters of various designs, and switchboard material of considerable toughness is required in order to stand up under the heavy impacts

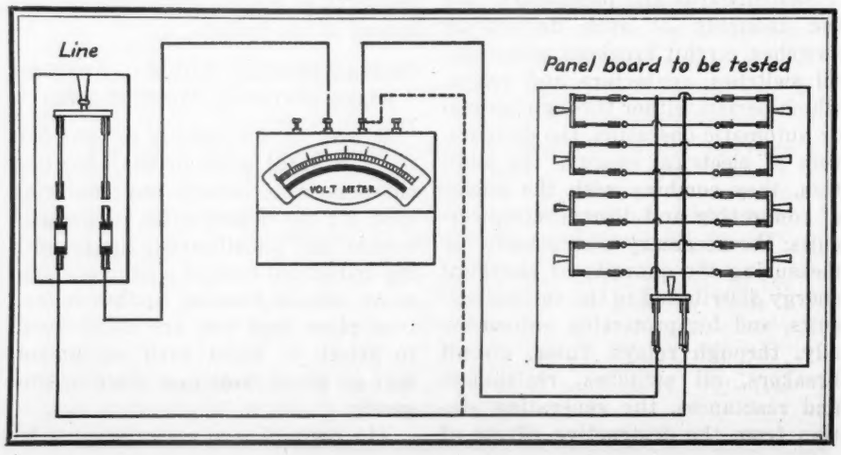


Fig. 1—Connections for determining insulation resistance of slate panel by voltmeter method.

The line voltage is measured with the voltmeter connected as shown by the dotted line; then the voltage is again measured with the dotted connection removed. The resistance of the voltmeter can be obtained from the instrument and, with these three quantities known, the resistance of the panel can be calculated by the use of a simple formula, as explained in the text.

caused by the opening and closing of the magnetic switches and contactors.

(5) Material used for electrical insulating purposes must be practically non-absorptive. Due to the wide range and quick variation in temperature to which electrical apparatus is subjected, there is very often a danger of leakage due to surface condensation and moisture.

(6) The expansion with rise of temperature should be so slight as to avoid the possibility of setting up destructive stresses with changes of temperature.

Coming now to the materials that possess the above qualities in sufficient degree to warrant their use, or consideration, for such purposes, slate is widely used for mounting both switchboards and industrial control apparatus. Other materials used for switchboard and similar construction are marble, either the Blue Vermont or Pink Tennessee variety; synthetic substitutes in the form of boards made from asbestos and magnesia fiber mixed with hydraulic cement, compressed into shape and saturated with an asphalt compound; natural, fine-grained sandstone boiled in linseed oil; opaque black glass; and metal, as in the so-called all-metal, safety dead-front construction.

Composition and Properties of Slate for Electrical Use

Before discussing the properties of slate which make it valuable for electrical purposes, it may be well to consider what slate is and where it is obtained. Slate is a natural, fine-grained rock which possesses fissility or cleavage, the ability to be readily split along a certain direction. Briefly, slate is composed largely of chemical combinations of silica with aluminum and iron or magnesium, with varying, although small, amounts of other minerals or compounds including iron oxide and sulphide, graphite, and so on.

Roofing and structural slate is found in several states in the eastern, western and southern portions of this country. Usable electrical slate has, however, so far been found only in certain quarries in Vermont, Maine and Pennsylvania. The first step in extracting slate from its bed is to cut deep vertical grooves in it by channeling machines. These grooves are 6 or 8 ft. deep and spaced 6 to 10 ft. apart. After the channeling machines have cut the grooves, the slate is split by means of wedges into slabs 6 in. or more thick and removed from the quarry. Along with the good material there is a large amount of small pieces and waste that must also be removed. The average amount of waste in a quarry is 75 per cent of the total amount of material taken out.

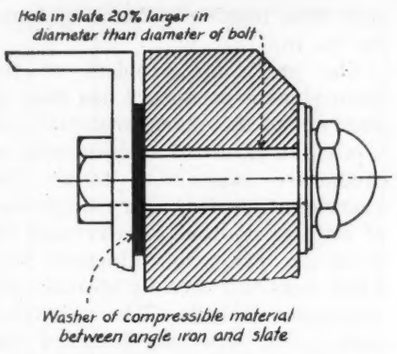


Fig. 2—Bolt holes in slate panels should be about 20 per cent larger than the diameter of the bolt.

Drilling the holes 15 or 20 per cent larger than the bolts will make assembly and alignment easier, and give some leeway for expansion or contraction of the panel. It is also good practice to place a washer of leather, fiber or other compressible material between the slate and the angle iron in order to lessen distortional stresses when the structure is tightened up.

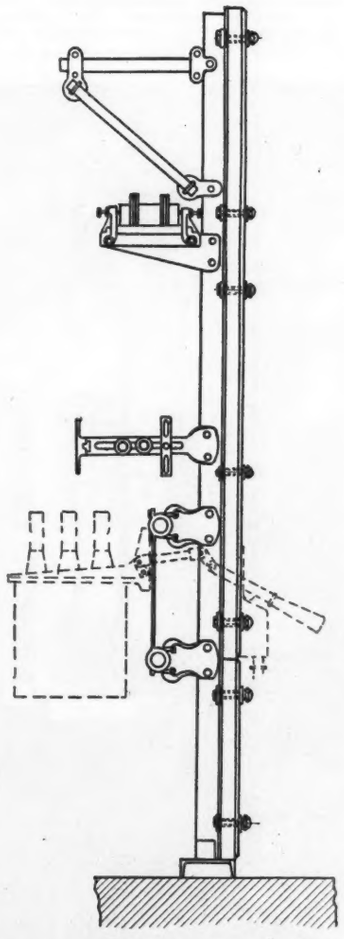


Fig. 3—The weight of the slate panels should be carried by a channel-iron base.

If the studs or bolts are allowed to carry the weight of the panels, the slate may be damaged. When the switchboard is subjected to much vibration or shocks it is advisable to place a strip of rubber packing or similar material between the slate and the angle-iron or channel-iron base. This illustration shows a typical oil switch assembly on a slate panel.

There are three main divisions in the uses of slate: roofing, structural, including electrical, and blackboards. If the slate can not be used for one of these purposes it should be suitable for either of the other two. The cost of extracting and finishing slate for any one of the three possible uses alone would make it so costly that it could not be marketed commercially.

After removal from the quarry the slabs which are usable for blackboards and structural purposes are taken to a mill and cut by large steel saws into the sizes required. From these slabs those which may be used for electrical purposes are selected, and split into the desired thickness. The surface of the resulting slabs is fairly even, but rough. The next operation is planing both sides; this gives an even surface which shows the marks of the planes. This planed surface is always left upon the back of slate used for electrical purposes, unless otherwise directed.

Following the planing operation, the slate is given one of two standard finishes. The so-called sand-rubbed finish is produced by rubbing the surface with sand and water. The resulting surface is smooth and even, showing a slight grain or stipple. This finish is sometimes called for on electrical slate, although in most cases the honed finish is preferred and is, therefore, furnished as standard. This finish is produced either by rubbing the slate with blocks of carborundum, with a stream of water running over the surface, or by smoothing the surface with a belt which is charged with fine carborundum and travels over the surface at a speed of 3,000 ft. per min. Unless otherwise specified the honed finish is always furnished on electrical slate.

There are four usual methods of treating slate panels, to produce the oiled, black marine, enamel, and marbleized finishes. These finishes are usually applied before complete installation, but if desired can be applied before shipment, although this must be specified.

The oiled finish consists of raw linseed oil rubbed in. It can be ap-

plied after all work of drilling is completed and gives the slate a clear black color. After installation and during constant use the color can, if necessary, be readily brought back by rubbing in a small amount of oil. This is the least expensive of all of the finishes.

The black marine finish was originated and is required by the U. S. Navy Department upon the electrical installations aboard warships, from which it derives its name. It is produced by the application of an amyl-acetate lacquer colored with black aniline dye, and is a dead black color. This finish gives a moisture-proof surface which has the peculiar quality of causing all water upon it to evaporate quickly. It is a long-lasting finish of good appearance and is called for frequently in electrical specifications where there is danger of moisture. This finish will not show stains from oil.

If any special tints or colors are required upon slate, it is possible to produce these satisfactorily by the use of lead and oil paint, which adheres well to the stone. The specifications for this painted finish may follow good accepted local practice, the same as for metal or wood, although it is not recommended that less than three coats be used and more properly four. If desired, it is possible to secure stained effects by the use of stains or wax, which should be applied and rubbed in with a cloth. In this way it is possible to secure a lighter effect, somewhat gray in color.

A large amount of investigational work has been done in determining the physical properties of slate, particularly with reference to its use in electrical installations, and for the sake of those who may be called upon to make use of this material, a brief resume of the results of these tests will be given. These tests were made on representative samples of slate of a grade suitable for use in switchboards and similar installations. For convenience, we may use the outline given above for the essential characteristics which switchboard material should possess.

Insulating Value—The average resistance of newly-quarried slate has been found to be on the order of 734,750 ohms per cu. in. Freshly-quarried slate contains a certain amount of moisture as a part of its crystalline structure. The influence of this moisture in reducing the resistance is shown by the fact that the average resistance of slate quarried three months is 2,535,700 ohms per cu. in.

The particular problem of the Pennsylvania producers has been to weed out of the quarry material containing an excess of carbonaceous or conductive material. Today, the quarries are testing every single slab of slate to be used for electrical installation prior to shipment with 2,200 volts and actually measure the impedance leakage. The apparatus used is an especially-designed test set which is covered by patent application. It consists of a step-up transformer in which the short-circuit current is limited to a predetermined safe value by means of a suitable resistance or reactance in the primary. This arrangement, through a corresponding adjustment in the ratio between primary and secondary coils, prevents an excessive voltage drop on slight leakage currents. A special, uniform-scale, dynamometer type of milli-ammeter is connected in series with the secondary of the transformer.

The tolerance limit of impedance leakage under a potential of 2,200 volts alternating current has been set at 20 mil.-amp., as slate at the quarries is by necessity tested while still containing moisture. Practical experience has shown that slate containing an excess of carbon gives leakages far in excess of this amount, and that slate still containing moisture as part of its crystalline structure and giving readings within the limits of the above-mentioned tolerance will, when dried out, give a leakage of only 2 to 5 mil.-amp. under 2,220 volts a. c.

Tensile Strength—Data regarding

Fig. 4—Here is a switchboard which is properly mounted on a channel-iron base.

This base carries the weight of the slate panels, so that none of it comes on the holding bolts. The arc shields between the circuit breakers on this switchboard are also made of slate.

the tensile strength of slate is seldom required. However, as a matter of information tests made upon 19 samples showed an average tensile strength of 3,625 lb. per sq. in.

Tests of the compressive strength made on a large number of samples of Pyramid brand slate showed on the average 10,250 lb. per sq. in.

Elasticity—This property was determined by several series of tests in which samples of slate 26 in. long, 1 in. wide and ½ in., 1 in. and 1½ in. thick respectively were arranged as beams on wood supports 24 in. apart. A load was applied at the center of the span and the deflection and breaking point noted. The following results are the averages of a number of tests: Beams ½ in. thick: average load at failure 68 lb.; average deflection 0.094 in. Beams 1 in. thick: average load at failure, 239 lb.; average deflection 0.0638 in.; modulus of elasticity, 9,437,000. Beams 1½ in. thick: average load at failure, 685 lb.; average deflection, 0.0793 in.; modulus of elasticity, 7,912,000.

Toughness—In testing slate for toughness, the method recommended by the American Society for Testing Materials has been used. Toughness, as applied to rock, is the resistance to fracture under impact, expressed as the final height of the blow of a standard hammer required to cause fracture of a cylindrical test specimen of given dimensions. A number of specimens of slate tested gave an average height of 11.5 cm. (4.5 in.).

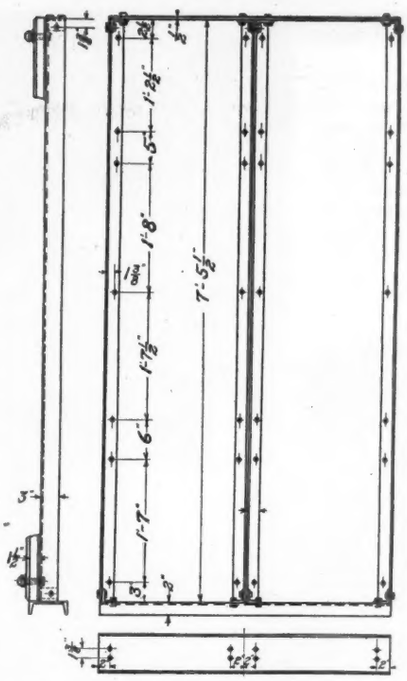
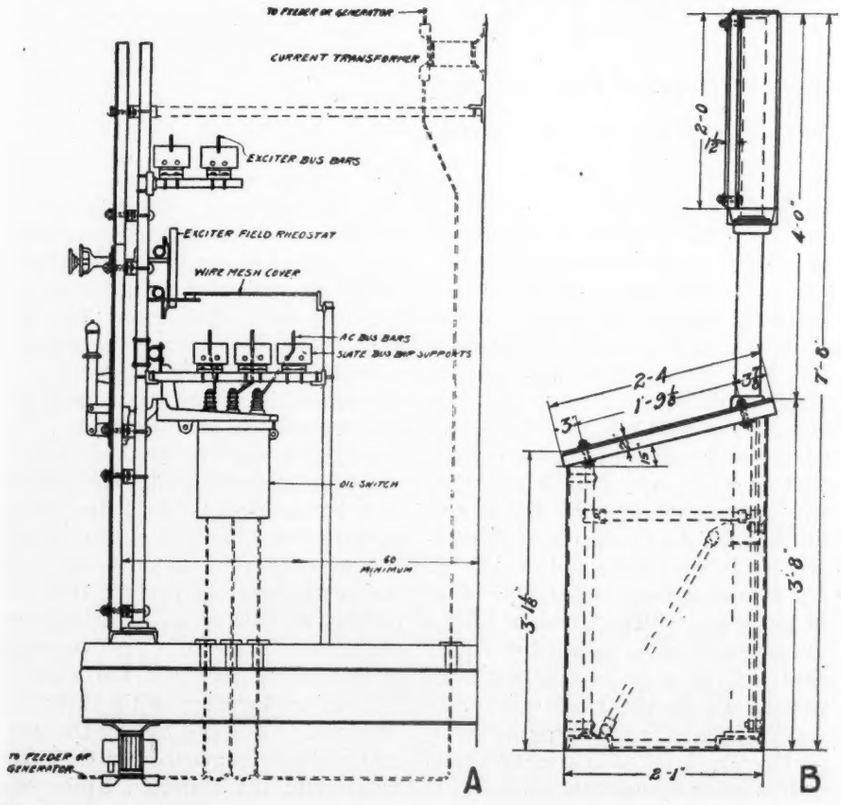


Fig. 5—Here is a typical angle-iron switchboard frame.
The dimensions shown here could easily be altered to suit local conditions.

Fig. 6—These are typical details of A, pipe-frame switchboard assembly and, B, a benchboard frame.
Note the channel-iron base on which the panel in *A* rests. The benchboard frame in *B* also rests on a channel iron. The compressible washers, between the slate and the frame are clearly shown in both of these illustrations. One of these washers is shown in detail in Fig. 2.



Absorption—This quality was determined by baking representative samples at a temperature of 120 deg. C. for 24 hr. and weighing. They were then immersed in water for 24 hr. and weighed again. Under these conditions, the average increase in weight was found to be 0.196 per cent of the dry weight.

Expansion—A large number of samples tested in an electric furnace at temperatures ranging from 10 deg. to 200 deg. C showed on the average a co-efficient of expansion of 0.00001.

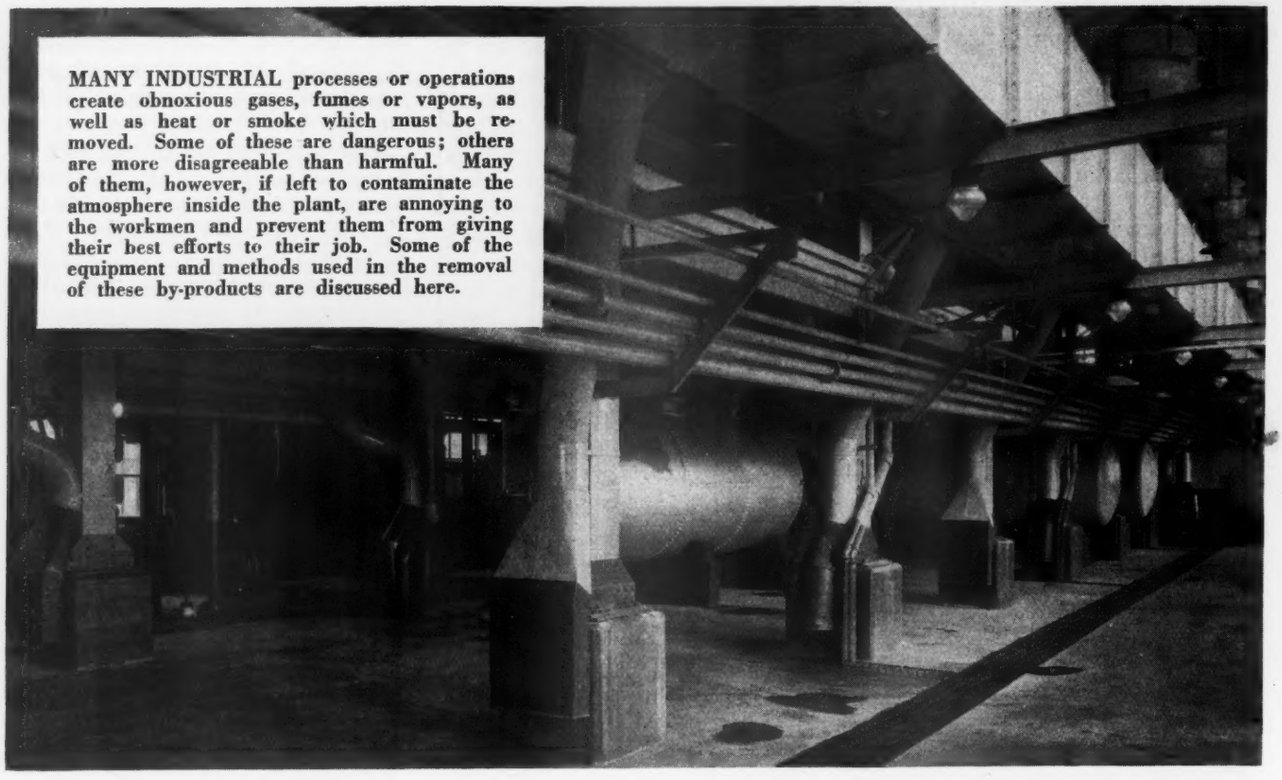
For practical purposes, these results are embodied in the accompanying specifications. These specifications can be used without prejudice for slate originating in Vermont, Maine, or Pennsylvania and call for the physical characteristics which are absolutely essential in material that is to be used for electrical appliances.

Method of Measuring Insulation Resistance of Slate Panels

In some instances it is desirable to determine the insulation resistance of a slate panel in service. This can be done in various ways, such as by means of a direct-reading ohmmeter, a Wheatstone bridge, or a milli-ammeter, although in practical work the most convenient instrument is the ordinary high-resistance voltmeter. The connections for determining the resistance by means of a voltmeter are shown in Fig. 1.

The theory of the voltmeter method of measuring insulation resistance is as follows: When a current flows through two conductors in series the volts drop across each of the conductors will be proportional to the resistance of that conductor. Then with an unknown resistance, *Rx*, connected in series with the voltmeter across the source of potential the volts drop across *Rx* will be proportional to its unknown resistance. Also, volts drop *Vv* across the resistance of the voltmeter, as indicated by the reading of the instrument itself, will be proportional to the resistance of the voltmeter. The proportion may be written Vv÷Vx =Rv÷Rx, or Rx (in ohms)=(Rv× Vx)÷Vv. In these formulas, *Vv* is the voltage drop across the

(*Please turn to page 306*)



MANY INDUSTRIAL processes or operations create obnoxious gases, fumes or vapors, as well as heat or smoke which must be removed. Some of these are dangerous; others are more disagreeable than harmful. Many of them, however, if left to contaminate the atmosphere inside the plant, are annoying to the workmen and prevent them from giving their best efforts to their job. Some of the equipment and methods used in the removal of these by-products are discussed here.

When fumes or vapors are heavier than air they settle to the floor and so exhaust outlets must be placed low. Here at the Deepwater Point du Pont Dye Works the floor suction openings discharge into the square duct overhead. Fresh air is discharged from round pipes overhead.

Some Things It Pays to Know About

Removing Obnoxious Fumes, Gases and Vapors

Which Are Generated During Industrial Processes, Together With a Discussion of Equipment and Methods Commonly Used

By CHARLES L. HUBBARD

Mechanical Engineer, Boston, Mass.

REMOVAL from manufacturing plants of objectionable substances, such as fumes, gases or dusts, whether in the atmosphere or created by the industrial processes, together with some of the lighter-weight materials, has become a matter of importance and in many cases of legislation or factory inspection regulations which specify the manner and operation of such removal. This is a problem which has wide distribution among various industries and a general consideration of its ramifications as well as methods of solution would seem to be of interest to industrial plant men.

The first point to take into consideration in the removal or repression of all of these objectionable substances is that they will, for a time at least, remain suspended in air. Naturally, it may be expected that a sufficient supply of fresh air, together with adequate removal of the impure air, partially or wholly saturated with the gases, fumes, vapors, dust or other objectionable material, will take care of practically any problem. This is the case; the exception is where the so-called fresh air is also contaminated with dust or some odor. The problem of the industrial man is to so direct this draft of fresh air as to remove the impure air in the most economical way and in such a manner as to interfere the least with the industrial processes or operations involved. If this point is kept in mind in planning for the removal of these undesirable industrial creations, the problems will be much simplified.

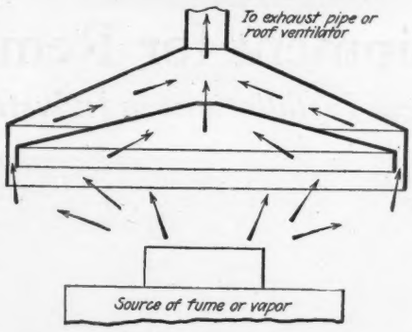
The equipment for handling these substances varies somewhat according to their nature, and final details of construction are frequently best left to those making a specialty of this class of work. Manufacturers of equipment for the purpose generally offer advisory or consulting service in connection with the installation of their equipment. The superintendent or engineer in charge, however, should be familiar with the characteristics of the waste products of his plant and the general type of the devices used or methods applicable for their removal. He is then in a better position to judge intelligently the importance and necessity of such removal, and plan the best methods or equipment. It is the purpose of this series of articles to enumerate some of the common wastes which occur in the various industries, together with their effect, and to describe briefly the general methods employed for their removal and the standard equipment

which may be used for this purpose.

Ordinarily, outside air is satisfactory for ventilation although this is not always true in all industries and locations. Generally, it is only necessary to remove the dust from the outside air, although this is not always sufficient, as will be explained later in this article, which will discuss fume, gas and vapor removal.

Some fumes, gases or vapors may have the appearance of being harmful, although they are only moderately so if carefully collected and disposed of, while others, which are less noticeable and often more dangerous, are entirely overlooked. In some industries where the presence of such objectionable by-products is a serious problem, their disposal is looked after very carefully; in other industries, where this is an incidental problem, it may be overlooked.

Fumes may be pungent, acid, corrosive and poisonous, depending upon the particular chemical or process producing them. Because there are so many different diseases or other serious consequences which may result from inhaling some of these fumes, each plant must study its own problem carefully. The most serious hazards occur in plants manufacturing chemicals or chemical products. During the war, an extensive study was made of the fumes created in the manufacture of explosives, together with the effect on the workers and the methods of safeguarding them.

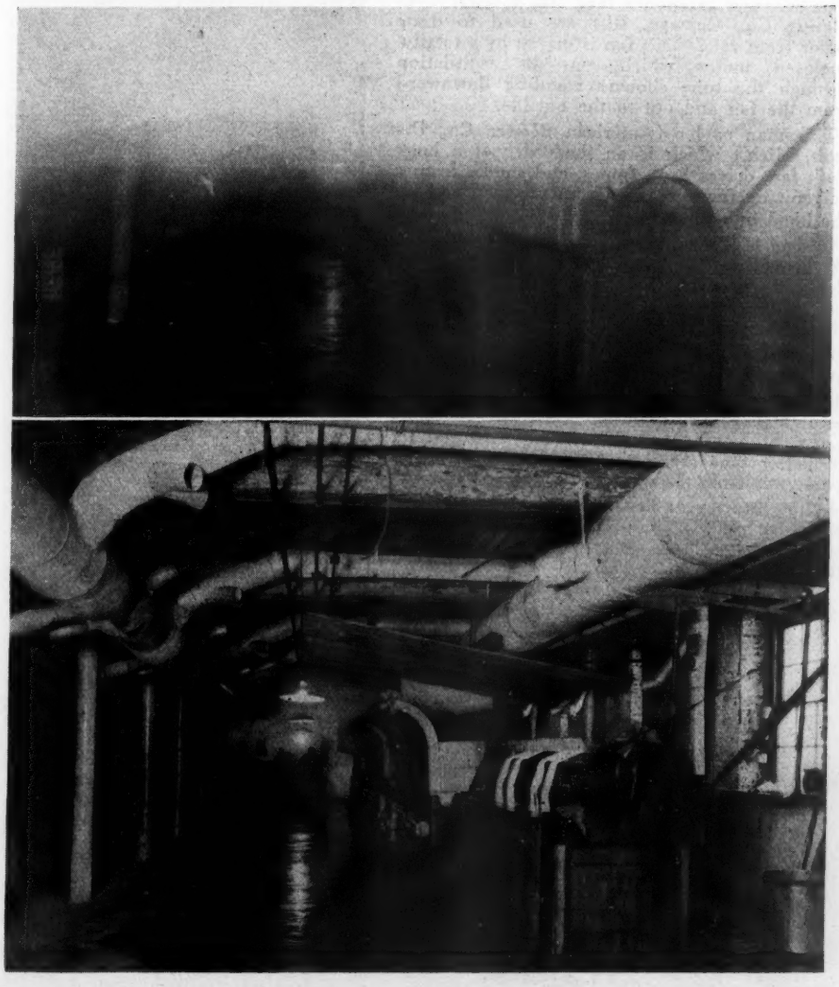


Double hoods, such as this, create a high velocity circulation of air through the narrow slot around the edge of the hood and prevent the escape of fumes ino the room.

Men in this and other chemical industries are generally familiar with the hazards and the methods of overcoming them so that problems incidental to the treatment of the more hazardous gases and fumes will be treated rather lightly in this article. However, the general principles employed in their removal are not different from those used with products less dangerous. The main problem in removing the more dangerous fumes or gases is to exhaust them surely and quickly before they have had an opportunity of escaping and diffusing into the room. Even then workers must wear respirators, hoods or masks for their protection, which, however, does not decrease the necessity of exercising every precaution to remove the dangerous fumes or gases.

The reason for gas or fume hazards in the average plant of any except the chemical industry, lies in the fact that injurious gases or fumes are produced in probably only one or two of the many operations or processes in the whole plant. In other words, such hazards are connected with a minor part of the industry and are outside of the ordinary experiences of the men in the plant. The most common industrial uses of acids which generate fumes, sulphuric, hydrochloric (muriatic), nitric and hydrofluoric acids, are in the pickling of iron or steel before galvanizing, tinning, enameling or applying some other coating or finish. Some of the other industrial processes which give off gases or fumes due to the use of acid, which should be removed, are the manufacture and charging of storage batteries, the manufacture of wood pulp, hats, leather, fertilizer, rubber, candles, glue, vinegar, and numerous other products, as well as in electroplating, etching (both of copper and glass), bleaching, dyeing, cleaning and in producing special finishes on brass, copper and other metals.

Alcohol, particularly wood alcohol, gasoline, naphtha, benzine and benzol fumes are both poisonous and explosives and so must be removed.



Two views of the same installation which show the effect of using the exhaust system.

In bleaching, dyeing and finishing in textile mills, the steam rising from the process would create such a fog that it would be almost impossible to work, as the hot, moist atmosphere makes workers sluggish. The upper photograph was taken when the exhaust system was not in operation. The lower of the two illustrations shows how conditions changed after the ventilating equipment had been operating exactly three minutes. This installation was made by the American Blower Company, Detroit, Mich., at the Valkone Dye and Finishing Works, Philadelphia, Pa.

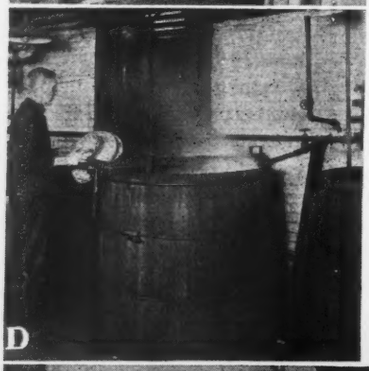
Types of Equipment for Removing Fumes

Nine Typical Installations in Industrial Plants

A

B

C



D

A—Here 78, 18-in. roof ventilators (Globe Ventilator Co., Troy, N. Y.) are installed on the machine shop of the Heald Machine Co., Worcester, Mass.

B—Another type of roof ventilator (B. F. Sturtevant Co., Boston, Mass.) is used on this shoe factory. The wind blows into the small end of this ventilator and aspirates the air from the building as it passes through.

C—These propeller fans (Autovent Fan & Blower Co., Chicago, Ill.) placed in the window draw warm, dry air past sheets of sandpaper to speed the drying of the glue.

D—In this case, propeller fans (Ilg Electric Ventilating Co., Chicago, Ill.) are used to draw vapor from vats. This fan is driven by a totally-enclosed motor which gets its ventilation through the tube shown extending downward from the fan and out to the outside.

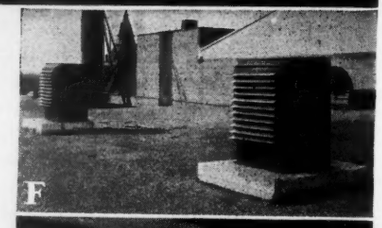
E—This man cooler (American Blower Co., Detroit, Mich.) which is on the order of a huge desk fan, drives heat, fumes, and smoke from a galvanizing furnace away from the men and up the hood into the flue.

F—Instead of depending upon natural ventilation, Ilg propeller fans are placed in pent houses on the roof and draw the vapors out of the building. The shutters on the front automatically close when the fan is not in operation.

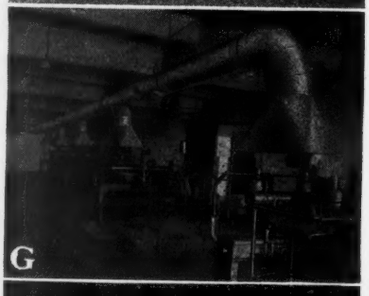
G—An Autovent blower in connection with an exhaust pipe and hoods over each machine is used to remove fumes and heat.

H—In mechanical painting (W. N. Matthews Corp., St. Louis, Mo.) three totally-enclosed Ilg propeller fans are used to draw the paint vapors away from the operator.

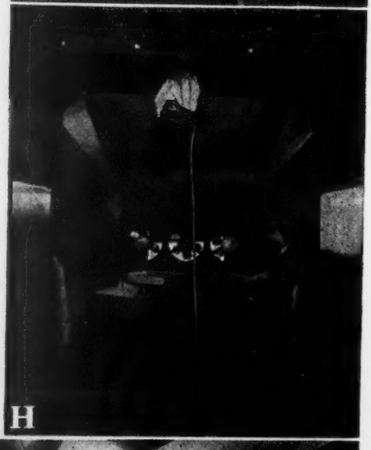
I—In this Sturtevant installation in a hat factory, each machine is closely covered with a hood connected to a main exhaust line which removes the vapors without permitting them to diffuse.



F

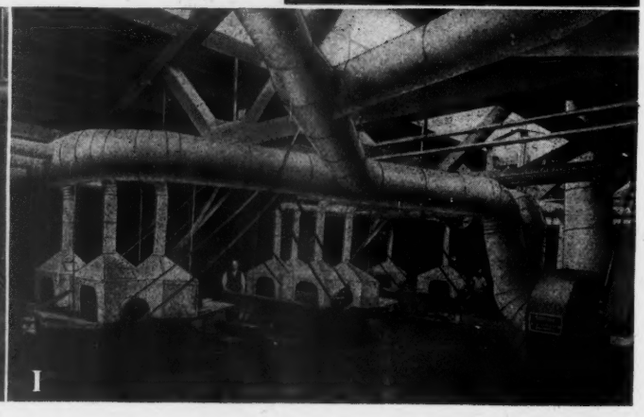


G

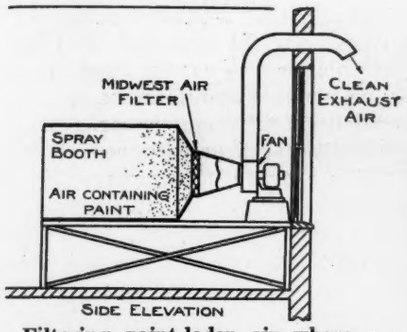


H

E

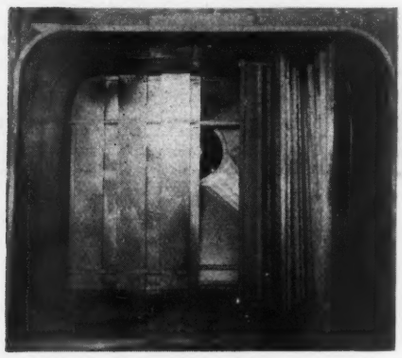


I



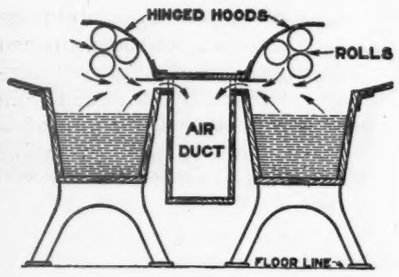
Filtering paint-laden air where a paint gun is used.

In mechanical painting booths the volatilized paint must be drawn away from the operator. To prevent the paint clogging the fan or discharging in the open, one method of removal provides for the insertion of a special air filter at the outlet of the booth and ahead of the exhaust fan, as shown in the accompanying sketch. In this way the paint is removed before it reaches the fan and so does not affect the fan nor contaminate the atmosphere. These filters, one type of which is made by Midwest Air Filters, Inc., New York City, are removed and cleaned by dipping them in a special solvent which removes the paint.



One method of preventing paint vapors from being discharged into the atmosphere.

Where it is not desirable to permit paint fumes generated by the paint gun to be removed through the exhaust system and discharged out into the air, a scheme such as this may be used. Here a special baffle is erected in the back of the paint booth between the painting operation and the exhaust fan. This baffle consists of sheet metal channels so arranged that the direction of the air is changed several times before it gets through to the exhaust fans. As a consequence, the paint is deposited on the baffles. These may be cleaned by putting them in a solvent, although generally a grease, paraffine or some other coating is placed over the baffle. When the baffle is dismantled and placed in hot water this coating is dissolved and carries the paint away with it. This is one method recommended by The DeVilbiss Manufacturing Company, Toledo, Ohio.



Another method of removing steam and vapor before they become diffused in the room.

Here the inlet to the air duct, which is connected to an exhaust fan, is placed so as to draw the incoming air past the operator, over the vat and directly into the duct. This arrangement is used in connection with a sizing machine in a hat factory.

Ammonia fumes are also irritating.

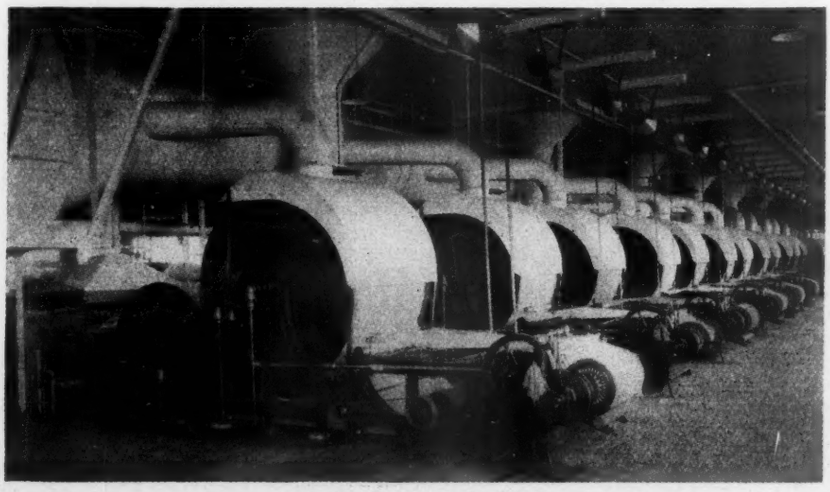
Melting and casting of lead, brass, and some alloys also may cause poisonous fumes. Heat-treating furnaces, particularly if cyanide is used, must also be guarded against. In mechanical painting or the application of other finishing materials by means of an air paint gun, some method of protecting the worker from the lead in the paint, which is frequently carried in a poisonous solvent which is volatilized in the air by the operation. This solvent, in many instances, is also somewhat poisonous, or at least obnoxious.

Some processes create non-poisonous water vapor which needs to be removed. Frequently, however, objectionable fumes are mingled with the water vapor and so make its removal imperative. Water vapor is formed, for example, in paper-machine rooms, foundries, bleacheries, dye-houses and finishing rooms, hat factories, laundries and other places where evaporation takes place from drying material or from an open bath of hot liquid.

An excess of moisture in the atmosphere is objectionable in various ways besides the enervating effect upon those subjected to it. A hot, moist atmosphere, which causes the formation of a fog, seriously interferes with rapid and efficient work on the part of the employes. Also, the condensation which settles upon the ceiling or other overhead structure of the building produces rapid corrosion or deterioration and also causes damage by dripping upon the materials in process of manufacture. This could not be permitted in textile, food products and many other industries where the product would be made valueless, perhaps, by the introduction of foreign material.

Some of the Methods of Removing Fumes, Gases and Vapor

A general rule to be followed in the removal of fumes and vapor is to catch them at their source, insofar as possible, and prevent their becoming diffused throughout the room. Where the quantity of obnoxious gases is small, so as to be well diluted with air, general room ventilation may be sufficient, in many cases, to maintain the necessary degree of purity. Many buildings are provided with skylights and monitor construction which can be opened to permit impure air to escape. A few open windows in the lower part of the building, in warm weather, will admit incoming air and create an upward draft which carries the fumes or vapors up and out. However, it is well to remember that either the monitor windows on both sides be opened or, particularly in winter, only the monitor on the side opposite the wind be opened. Otherwise, the force of the wind will drive in-



Hot, moist air is removed from 18 slashers by a specal hood and exhaust system connecting to a central exhaust pipe.

The hoods fit down closely over the cylinders and prevent the moisture from escaping into the room, where it would condense on the ceiling and perhaps drip on to the product. In case a slasher is shut down, the hood may be closed off by the special damper in the pipe just above the hood. This installation was made by the B. F. Sturtevant Company, Boston, Mass., at the Riverside Cotton Mills, Danville, Vt.

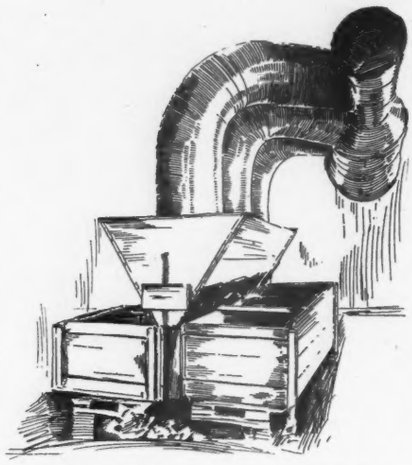
coming air down and so retain the fumes or vapor in the room, instead of removing it. Monitors or skylights are frequently satisfactory in connection with the removal of a certain amount of smoke, fume or light dust arising from the general operations in the industrial plant.

In general, hoods connected with a strong outward draft, should be fitted over the source of the offensive product as closely as practicable without interfering with the working space required for the operative. Sometimes hood and general room ventilation may be combined to good advantage, thus securing better results for a single cost of operation. In handling a fume or gas of any kind, the first point to be ascertained is whether it is lighter or heavier than air. If lighter, the hood and exhaust opening should be located above, so that the gas will naturally rise into it when accelerated by the induced draft.

This may be illustrated by the case of a forge shop where ventilation is best accomplished by placing a hood over each individual forge and connecting it with the trunk line leading to an exhaust fan. This not only catches the smoke and gases as they arise from the fire but also furnishes a certain amount of general or room ventilation when supplemented by an abundant supply of fresh, tempered air to replace that which is constantly drawn off by the hood. Frequently monitor roof construction is also used to draw off any gases which escape the hood, as well as the heat of the forging operation.

The form of hood and velocity of flow both have an important bearing upon the effective removal of gases which are lighter than air. In the case of those gases or fumes which are not especially offensive, or where they are well mixed with air, good results are obtained when the lower edge of the hood is placed about 18 to 20 in. above the point where the gas is produced, providing that the edges of the hood have a good overhang and the air velocity is not less than 200 ft. per min. over the entire bottom of the hood.

It is sometimes necessary in the application of fans for the removal of smoke and fumes, to so design the hood that it will not be in the way of the workman and still be capable of catching the noxious gases before they get into the room. Most failures in such installations are due to the hood being too small. To determine the dimensions for such a hood, it is good practice to make the mouth of the hood extend out over the kettle or furnace at least 6 in. in every direction, when the hood is not elevated over 2 ft. above the surface of the kettle or furnace. For every additional 2 ft. of elevation, the size should be increased 6 in. each way.



Here the fumes are removed before they rise high enough to get to the worker.

The inlets to the exhaust pipe are placed low, just above the edge of the vat, so that they can draw off all obnoxious fumes or vapors before these diffuse into the room.

Ordinary practice is to make the area of the branch pipe at least 1/16th of the hood area. For instance, a furnace 2 ft. by 4 ft. with the bottom of the hood 4 ft. above it would take a hood 4 ft. by 6 ft. The area of the pipe would be 1/16th of this, or 1½ sq. ft. The branch pipe should, therefore, be approximately 17 in. in diameter, and the velocity at the mouth of the hood under average conditions would be between 100 and 200 ft. per min.

It frequently happens in manufacturing processes that poisonous and noxious gases have to be removed in a more efficient manner. If the plant engineer should attempt to exhaust sufficient air through a hood to create enough suction at the mouth to gather in all the fumes, the size of the pipe and the quantity of air to be handled would frequently be out of all reason. This situation can be very satisfactorily avoided by the use of a double hood with about an inch clearance between the outside and inside sections along the edges. The inside hood is then tapered back and the pipe is so connected that sufficient air is drawn up around the edges through the small area between the inside and outside sections to create a velocity of about 1,000 ft. per min. in this slot and about 75 to 100 ft. per min. over the central area. A high velocity, therefore, exists around the edge of the hood and any gases that do not naturally rise into the central opening are sucked in before they escape into the room. Two of the sketches reproduced with this article show how these double hoods are constructed and installed.

Fumes which are heavier than air, such as those from storage batteries, gasoline, and the gases formed in brass and iron foundries, require a somewhat different treatment. In most cases of this kind, a downward

(*Please turn to page 304*)

Vapor-proof lighting fixtures are necessary features around explosive or inflammable gases.

In this du Pont installation individual hoods are placed over the charging hoppers. A main floor exhaust duct is located in the right foreground, with fresh air supply ducts along the right-hand wall and also in the center bay of the building, near the ceiling.

Methods of

Taking and Recording Rewinding Data

On D.C. Armatures so That the Details of the Winding Can Be Readily Understood and the Job Handled Properly by Any Winder

By A. C. ROE

Renewal Parts Engineering Department, Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.

HOW OFTEN DOES it happen that, after an armature has been stripped, it is found that someone has forgotten to notice or record some important detail of the rewinding data? Mistakes of this kind are often costly. In this article Mr. Roe describes several systems for taking down the complete data in such a manner that any winder can readily understand and use it and which will insure that all of the important data are recorded.

WHEN repairing direct-current armatures, particularly when it is necessary to remove the old winding and rewind the armature with new coils, it is essential that the winding data be recorded in a manner that is easily understood by other winders in the shop. By winding data, we refer to such connection information as lead pitch, lead throw, coil pitch, and the like. There are several rules and methods for taking data; also, each type of winding has its own peculiarities. Therefore, this article will be confined to describing the various types of connections and the methods of taking and checking the rewinding data necessary for them.

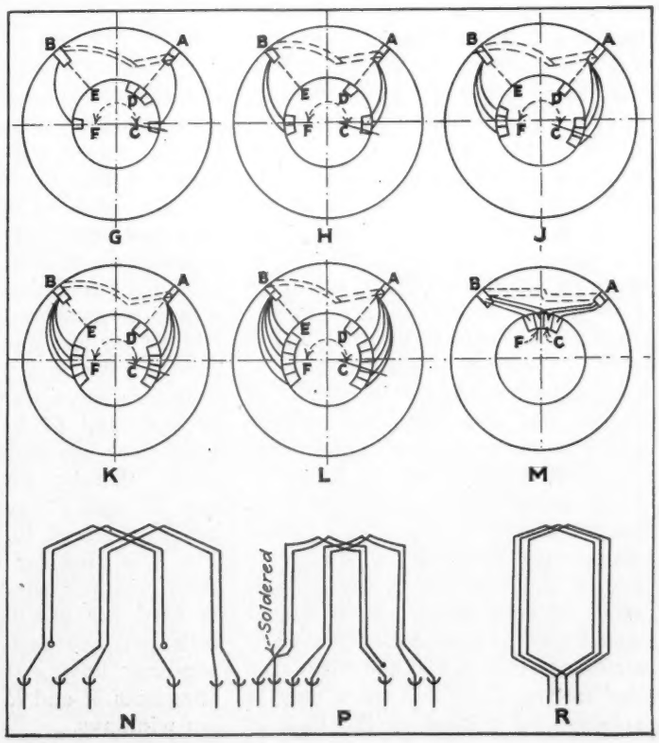
The first step is to develop a system of recording the data that are required in the armature winding room. This usually consists of a card filing system or blank notebook in which each winder puts his notes. In some shops, a blank form has been developed which standardizes the method of taking and listing the data. In any system that may be used for recording this information, the following are the items that should be listed in order to insure that sufficient information has been taken to rewind the armature in the correct manner:

(1) Order number to which all time and material are to be charged.
(2) Customer's name or department to which the armature belongs.
(3) Nameplate rating of the motor, that is, the horsepower, voltage, speed, number of poles, type, frame number, and any other identifying marks that may be on the nameplate.
(4) Number of slots in the armature.
(5) Total number of bars.
(6) Turns per coil.
(7) Size of wire.
(8) Number of wires in parallel per coil, or the number of wires per commutator bar.
(9) Pitch of coil.
(10) Number and size of bands; that is, the width and location of the band. Size of banding wire.
(11) Style number of armature.
(12) Serial number of armature.
(13) Distance that the end winding projects beyond the core, and in some cases, the distance between the bottom of the winding and the shaft.

Figs. 1 and 2—Here is a very comprehensive method of taking armature data.

The data are recorded on cards made up in a manner similar to that shown in Fig. 1. Reference is made to sketches shown in Fig. 2 for specific dimensions, depending upon the type of winding that is used. Fig. 2 may be printed on the back of Fig. 1, or each winder may be provided with a chart similar to Fig. 2. Details regarding the use of each sketch in Fig. 2 are given in the text of this article.

MOTOR Type K R Frame 56
H.P. 100
SERIAL NO. 43984
VOLTS 600
NO. ARMATURE SLOTS 39
NO. COMMUTATOR BARS 195
REFER TO FIGURE L
THROW OF COILS, A-B 1-10
THROW OF LEADS: RIGHT, C-D 1-24; LEFT, E-F 1-30; TOTAL, C-F 1-91
REMARKS 5 bands - 3 on core - one 2" each end
Left-hand coils end room = 4 7/8"



(14) Distance from the front of the commutator bars to the end of the shaft or oil thrower, or any other fixed point that will insure the commutator being pressed to the right distance on the shaft.

Item 13 is very important because in a large number of the older types of motors, the end housing has ribs on the bearing housing which project into the frame along the shaft and if the winding drops down or projects too far, it will rub. A winding that is otherwise good may thus be ruined.

Item 14 is important when the commutator has to be removed from the shaft for repairs, particularly so if the field frame is not in the shop and it is desired to press the commutator to the correct position on the shaft so that it will not interfere with other parts of the motor.

We will now consider a number of different forms that have been used for recording the data that we have just described. A simple form that may be used for both lap and wave windings is shown in Fig. 3. In this form, space is provided for recording the nameplate data as well as the number of slots and number of commutator bars. At the top of the form are two sketches: The one at the left is for use with wave windings and the one at the right is for use with lap windings. On these sketches, the dimension *AB* is the coil pitch and is recorded in the proper space on the form. In determining the coil pitch, *AB*, *A* is the slot in which the bottom conductor lies, and *B* is the slot in which the top conductor of this same coil lies. For wave windings, the following lead throws are also recorded: *EF*, which is the top lead throw; *CD*, which is the bottom lead throw; and *CF*, which is the total throw of the leads, or the lead pitch. In using the wave winding sketch, that is the diagram at the left, for windings having three or five coils per cell, the middle coil should be used for laying off and taking the data.

A more comprehensive method of taking the data than the method just given is by the use of the forms shown in Figs. 1 and 2. Cards or blank pages may be printed in a manner similar to Fig. 1, or a rubber stamp may be made up similar to Fig. 1, and stamped on any suitable sheet of note paper. Each winder would then be provided with a blank similar to Fig. 1, and one chart similar to Fig. 2, or this chart may be stamped or printed on the back of the data sheet. Then, in recording the data, the winder would fill in the seventh line of Fig. 1 with the proper reference to the particular diagram in Fig. 2 that was used.

When taking data on a wave winding that has the same number of

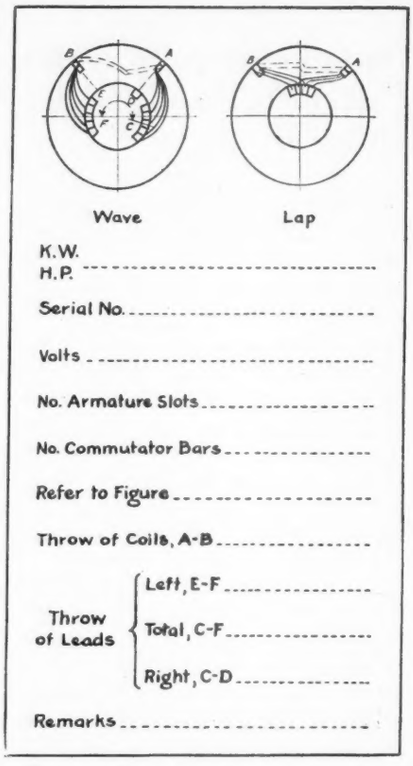


Fig. 3—This simple form may be used for both lap and wave windings.

The coil throw and lead throw are measured as indicated by the diagrams at the top of the form. The diagram at the left is for wave windings, while that at the right is for lap windings.

slots and commutator bars, reference would be made to *G* of Fig. 2, in the seventh line of the form shown in Fig. 1. If the wave winding has twice as many commutator bars as slots, reference would be made to *H* of Fig. 2. If the wave winding has a dead coil, reference should be made to both *H* and *N* of Fig. 2; for example, a winding having 49 coils and 97 bars. If the armature has a wave winding using 47 slots and 94 bars, and was intended for use with a four-pole machine, thereby giving a half-idle bar, *H* and *P* would be the diagrams referred to. Diagram *J* of Fig. 2 is used for windings having three coils per cell, while diagram *K* is used for windings having four coils per cell and diagram *L* for windings having five coils per cell. Diagrams *M* and *R* are for use with lap windings.

In the foregoing several simple methods for recording the rewinding data have been described. It will be found that the needs of many small repair shops for an adequate system of taking off winding data will be amply filled by the forms that have just been described, while the conditions encountered in large shops handling a great variety of motors will be met by the use of the system that will be described in what follows. This system is such that it will accommodate special windings and windings which have unusual features that cannot be easily described in the forms that have just been presented.

This system consists of the data sheet shown in Fig. 4, and the chart in Fig. 5. For convenience in filing and keeping the data so that they can be readily located at some future date, the forms shown in Figs. 6 and 7 may be added.

The data sheet, shown in Fig. 4, will cover practically every case met with except that of special cross-connected armatures, having taps to slip rings. This form can be made up on a rubber stamp about 4 in. by 6 in. in size, and stamped on the pages of an ordinary notebook. It is better, however, to furnish each winder with a number of 4-in. by 6-in. printed cards similar to the one shown in Fig. 4. The winders record the data for each job on these cards and then turn them over to the foreman, who places them in a card file. While the jobs are in process, the cards are filed under the customer's name. After the job is completed, the cards are placed in another file and arranged according to the name of the manufacturer of the armature that was repaired; that is, Westinghouse, General Electric, Century and so forth. As the group of cards under each manufacturer's name becomes larger, the cards can be subdivided into groups according to horsepower, and, later, as the number of cards becomes still larger, each group under one horsepower classification can be subdivided into smaller groups classified according to speed and voltage. This is a valuable record for any shop to have. Often an armature is received for repairing and there is some doubt as to the way it should be rewound. If a check is made in the card file on the same type of armature it will often be found that the job received has the wrong size of wire or that some important detail is not standard.

The top line of the form shown in Fig. 4 provides a space for the order number and the customer's name. On the next line are recorded the horsepower, voltage, speed, and full-load, ampere rating of the motor. The third line provides a space for the name of the manufacturer of the motor and the type and frame size. The number of bars and slots and also the number of wires per bar (W-B) are recorded on the fourth line. The term "wires per bar" means the number of active leads from the coils that connect to one commutator bar and does not include any dummies or fillers. This is a check upon the number of wires used in winding the coil. For instance, let us assume that we are winding an armature having 71 bars and slots and four wires per bar, using three turns of No. 11 double-cotton-covered wire. Since one-half of the number of wires per commutator bar equals the number of wires in parallel per single coil, the coils for this armature would be wound with three turns of two No. 11 double-cotton-covered wires in parallel. Let us take another case of an armature having 55 slots, 165 commutator bars, four wires per commutator bar, and using two turns of No. 10 double-cotton-covered wire. In this case we have three times as many commutator bars as slots and consequently each winding unit or complete coil will consist of three single coils, each single coil being wound with two turns of two No. 10 double-cotton-covered wires. Each winding unit or complete coil will have twelve leads; that is, six top leads and six bottom leads.

Recording the data by using the number of wires per commutator bar, the number of turns per coil, and the size and kind of wire is a better check than putting the coil data down as two turns of six No. 10 wires, or in some cases, three turns of two No. 15 wires. In the latter case, there is a chance of reading this information as three turns of four No. 15 wires when there are twice as many bars as slots.

On the fifth line are recorded the turns per coil, and the size and kind of wire used; that is, No. 10 square d.c.c., and so forth. Any marking or numbers appearing on the shaft are put down on the sixth line.

The banding information is recorded on the seventh line. This is very important and should include not only the size of banding wire used but also the location and overall size of the band. The width of the end band should be noted and in the case of high-speed machines special attention should be paid to the kind of banding wire that is used. The spacing of each wire in the various bands should be noted and in the case of wide bands it should be determined whether they

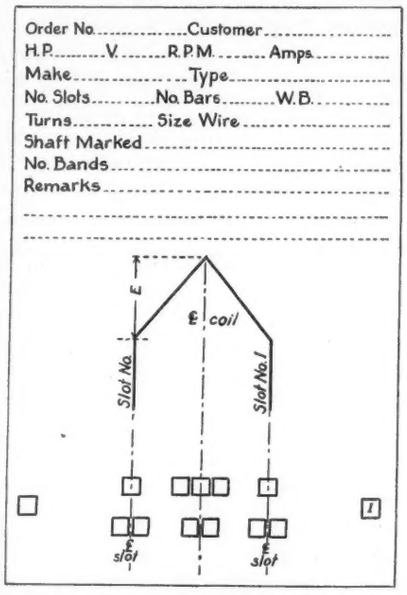


Fig. 4—Here is a data sheet that is very flexible and will fit practically every case encountered, except that of special cross-connected armatures having taps to slip rings.

In using this form, the slots holding the top and bottom coil sides of one coil should first be located. Call the slot holding one coil side, slot *1*, and count from this slot as a base to obtain the number of the slot holding the other coil side. The commutator bars to which the leads of this coil are connected should be located next. These bars are indicated at the extreme right and left of the diagram. Finally it is necessary to locate what part of the commutator lines up with slot *1*. If slot *1* lines up with the center of a commutator bar, we would use the top row of bars shown in the diagram, and number it, counting from bar *1*. If slot *1* lined up with the mica between two bars, we would use the bottom row of bars shown in the sketch and number the bars on each side of the mica according to the distance from bar *1*.

are split into sections by the use of insulating material. In some cases it will be found that the core bands have a strip of tin of a width equal to the band, and which extends around the armature under the band. This is found principally on railway armatures. Using tin under a core band in place of insulation such as fullerboard or fibre will insure a tight band. Insulating material will dry out in time and the band will work loose, whereas with the tin strip, the banding wire is soldered directly to the tin thereby making a permanently tight band.

The last three lines of the form provide room for recording any other data that seems necessary regarding the winding. The dimension indicated at *E* of the sketch below the data is for recording the distance that the coil ends project beyond the coil.

In using the form shown in Fig. 4, the following procedure will be found very convenient for recording the data:

(1) Fill in data on upper part of card.
(2) Count number of slots and bars.
(3) Check for dead coil, half-idle bar, etc., and enter details under remarks.
(4) Locate the slot in which any top coil lead falls and call it slot *1*.
(5) Mark teeth on each side of this slot.
(6) Mark the commutator bar to which the lead selected connects and call it bar *1*.
(7) Check end room, and enter at *E* of sketch.
(8) Lift coils and locate slot in which falls the bottom coil side of the coil selected in (4). Using slot *1* as a base determine slot number for this coil side and record on sketch.
(9) Light out bottom lead. Using bar *1* as a base, determine number of commutator bar to which this lead connects.
(10) Mark slot holding bottom coil side of the coil selected at (4) and also mark the commutator bar to which the bottom coil side connects.
(11) Determine bottom lead throw.
(12) Count lead pitch.
(13) Count coil pitch.

In Fig. 5 are 13 different applications of the data sketch shown at the bottom of the form in Fig. 4. The layouts shown at *I, II, III, IV, V, VI, VII, VIII,* and *IX* are for wave windings. Those shown at *X, XI, XII,* and *XIII* are for lap windings. In *I*, Fig. 5, is shown the sketch for an armature having the same number of bars and slots and in which the brushes fall on the center line of the poles. As can be seen, the center line of slot *A* falls on the center line of bar *D*. Inasmuch as the coils per cell will equal the total number of bars divided by the total number of slots, in this case there will be only one coil per cell.

In *II* of Fig. 5, is shown a developed sketch for an armature having twice as many bars as slots and which also has a dead coil. Since there are twice as many commutator bars as slots there will be two coils per cell. In any winding having a dead coil and more than one coil per cell, the idle coil should be the first single coil on the right, as shown in *II* of Fig. 5. The dead coil should

be in the first complete coil or winding unit that is put in the armature. In the sketch shown at *II*, the center line of slot *A* falls on the mica to the left of bar *D*. This is an important part of the winding data and should be recorded as shown in the sketch. In *III* of Fig. 5 is shown the developed sketch for an armature having three coils per cell, all coils of which are active. In this case it will be seen that the center line of slot *A* falls on the center line of bar *D*.

The sketch shown at *IV* is for an armature having four coils per cell including one dead coil. The sketch shown at *V* has five coils per cell.

The sketches shown at *VI* and *IX* of Fig. 5 show two methods of recording the data for an armature having a half-idle bar; that is, for an armature having one bar too many. This type of winding is used on a number of the old machines in which the same armature or commutator was used for a lap as well as for a wave winding. As a lap winding generally has an even number of bars and a four-pole wave winding requires an odd number of bars, it follows that when an armature having an even number of bars is used for a wave winding, there will be one bar too many. For example, if an armature having 49 slots and 98 bars is used for a wave winding, it will be necessary to jump two bars together so as to make the equivalent of 97 bars, which would be required for this type of winding. In diagram *VI* this is accomplished by soldering the two top leads together at a convenient point and bringing two leads out from the junction to the two commutator bars as shown. The bottom lead of the right-hand single coil is dead-ended; that is, it is cut off and insulated from the adjacent bottom lead. The soldering together of the top leads forms a short jumper between bar *F* and the adjacent bar to the right. In connecting the armature, care should be taken that a bottom lead is not connected to the bar marked with a cross. The best way to avoid the possibility of this happening is to lay off the distance *CD* and *CF* when putting on the first coil and then fill the bar next to the right of bar *F* with dummies, or short pieces of wire of the same size as used in the coils.

Diagram *IX* of Fig. 5 shows the long-jumper method of laying off a half-idle bar connection. With this method the bottom lead of the right-hand single coil is soldered to the bottom lead of the second single coil. One lead from this junction is brought out to bar *C*, as is shown in the diagram. The two top leads are brought out to two bars, as shown at the left of diagram *IX*. The same precaution should be taken in laying down the bottom leads as was mentioned for the short-jumper type of

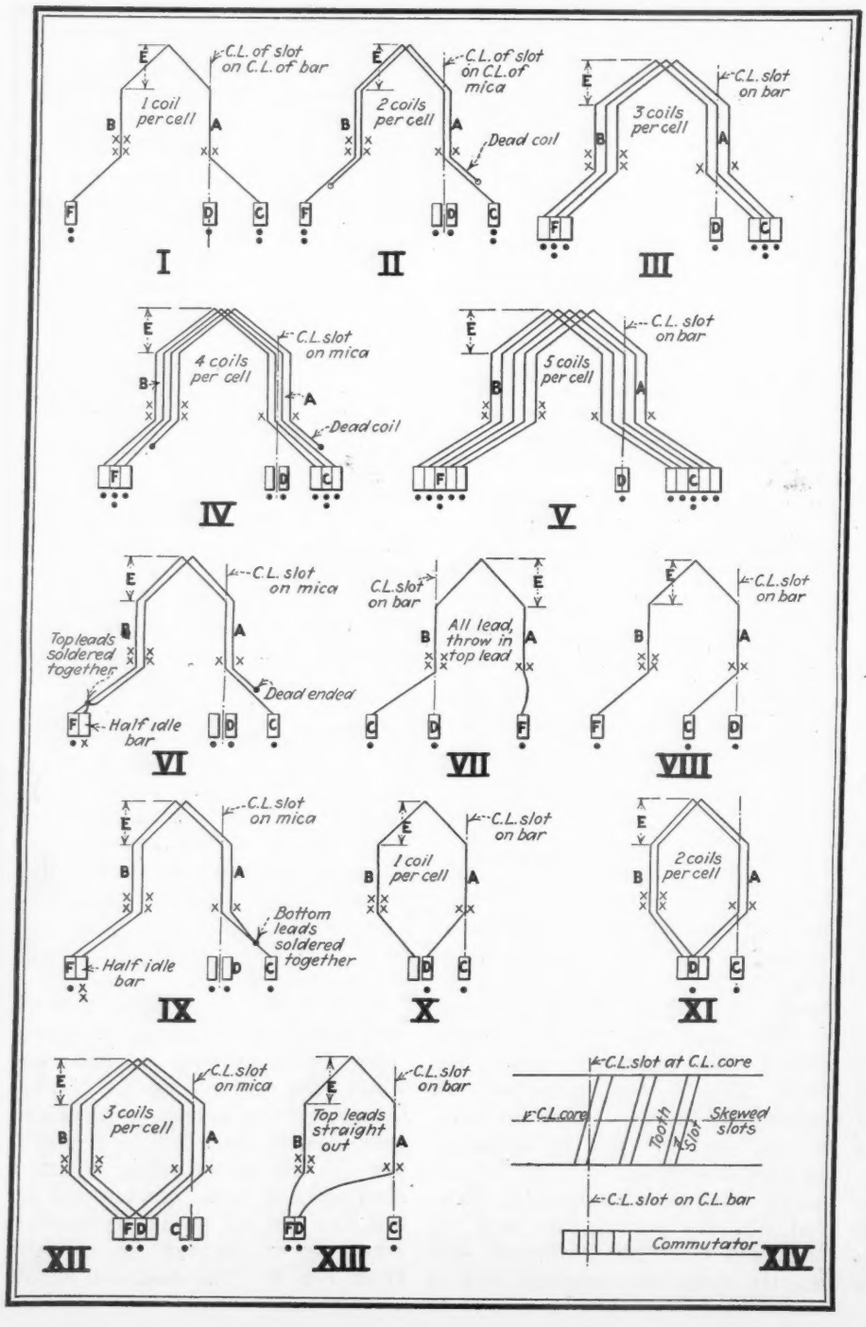


Fig. 5—These diagrams illustrate the method of recording data for lap- and wave-wound armatures. In all of these diagrams, the teeth on each side of the slot are marked with crosses. For instance, in diagram *I*, slot *A* falls between the crosses on each side of a coil side. Likewise, in diagram *II*, the crosses indicate the teeth on each side of a slot. Thus it is easy to see that in diagram *II* there are two coils per cell instead of two slots having one coil per cell. The slot holding a bottom coil side for any particular coil is marked with one cross on each tooth, as shown at slot *A* in any of the above diagrams. A slot holding the top coil side of any particular coil is marked with two crosses on each tooth adjacent to the slot, as shown at slot *B* in any of the diagrams. The dots placed beneath certain commutator bars in each of the diagrams represent center punch marks on the bars. These are used to distinguish the bars that are connected to the winding unit or coil that lies in the slots marked with the crosses. If there is more than one coil per cell, two punch marks are used to indicate the particular bars belonging to one coil. This is preferably the center coil of the group, as shown at *III*, *IV*, and *V*. In each case in the diagrams, *AB* represents the coil pitch and is measured in slots; *CD* represents the lead throw and is counted off in commutator slots; *CF* represents the total throw of the leads; that is, the lead pitch, and is measured in commutator slots. Diagrams *I*, *II*, *III*, *IV*, *V*, *VI*, *VII*, *VIII* and *IX* are for wave windings, while diagrams *X*, *XI*, *XII*, and *XIII* are for lap windings.

connection, described in the preceding paragraph.

Digram *VII* of Fig. 5 is for a wave winding in which the brushes are on the center line of the neutral region. The bottom leads are connected straight out, as shown, between slot *A* and commutator bar *F* in diagram *VII*. Hence, all the throw is in the top lead. The top slot is, therefore, used to locate the lead throw *CD*.

At this point, it might be well to draw the distinction between "lead throw" and "lead pitch." Lead pitch refers to the total distance, measured in commutator bars, between the top and bottom leads of any one single coil, as *CF* in *I* of Fig. 5. On the other hand, lead throw refers to the distance between a commutator bar which is in line with a slot containing a coil, and the bar to which one of the leads in the slot mentioned connects, as *CD* of *I* in Fig. 5. Consequently, in a wave winding with the brushes on the center line of the poles, there is only one lead pitch, but there are two lead throws: a bottom lead throw and a top lead throw. In some cases, the two lead throws are alike, while in other cases they are unequal.

Diagram *VIII* of Fig. 5 shows a layout for a wave winding that has the brushes on the center lines of the poles, and in which the arrangement of the winding is such as to prevent the bottom leads from having a right-hand throw. This would be the case in an involute winding, such as used in some of the early types of armatures made by the General Electric Company and the Otis Elevator Company. The bottom lead forms part of the coil and is brought over to the left and out at the center of the coil and connected to bar *C*. Notice that with this arrangement, the throw *CD* has been inverted, so as to preserve the meaning of *CF*, which is the lead pitch.

Diagram *X* of Fig. 5 shows the layout for a lap winding having one coil per cell, while diagram *XI* shows the layout for a similar winding having two coils per cell. Diagram *XII* shows a lap winding having three coils per cell.

Diagram *XIII* shows how the data are recorded for a lap winding with the brushes on the center line of the neutral region. The bottom slot *A* is used to locate the lead. This is more accurate than saying that the top leads are connected straight out, or connected 1-and-2, etc., as in most cases a fractional coil pitch is used. This means that the lead must have a slight throw and the method given in diagrams *X*, *XI*, *XII* and *XIII* will show this.

Diagram *XIV* of Fig. 5 shows the method used to line out from a slot to the commutator for armatures having skewed slots. Notice that the line starts at the center line of the slot at the center of the coil. In other words, don't line out from the commutator end of the core, but in every case drop back to the center of the core and to the center line of the slot.

S.O. ..... Customer .....
Hp. ... Volts ..... R.P.M. ..... Amp. .....
Make ..... Type ..... Frame .....
No. of slots ..... No. of bars .... W-B .....
AB ..... CD ..... CF ..... Fig. .....
Size wire ..... Turns per coil .....
Shaft marked .....
Size of band wire ..... No. of bands .....
Remarks .....
.....
.....

Fig. 6—This card may be used instead of the one shown in Fig. 4. The winder is provided with a chart similar to Fig. 5, and from this chart he selects the diagram similar to the winding on which he is taking data. The reference number of this diagram is recorded on the card in the space marked "Fig."

Fig. 6 shows a card developed for use with Fig. 4. This card provides for the same information as shown in Fig. 4, but in the fifth line the letters *AB*, *CD* and *CF* appear. These correspond to the letters shown in diagrams *I* to *XIII* of Fig. 5. The procedure followed is as given herewith:

Each winder is supplied with a chart similar to Fig. 5. In filling out the card, the winder first fills in the coil pitch *AB*. Then the lead throw *CD* is counted off on the commutator and recorded on the card. The lead pitch *CF* is next counted off and the reference figure (shown on Fig 5) that applies to this winding is then recorded on the card. After recording all the data, the card is turned in to the foreman and a card similar to the one shown in Fig. 7 is filled out. These cards are 8 by 10 in. in size. They are filed according to the manufacturer of the motor. In each manufacturer's section of the file the cards are again subdivided according to horsepower.

A card system is a great deal better than the notebook method of filing winding data, for after a number of notebooks have been filled with data it becomes quite a job to locate the data on an old repair order. For example, suppose we have a 10-hp. standard make of motor in the shop for repairs. The winding data that were taken do not seem to be correct and it is thought best to check with a previous repair job. With the notebook method of recording data, we would have to guess at the date at which we think a similar job was done and then pick up the book that we guess was used about that time. We then thumb through the pages until the required data are located. With the card system we would go directly to the section covering motors made by the manufacturer of the motor in question. In this manufacturer's section, we would then look for the card referring to motors of a certain horsepower and the desired data would be quickly found.

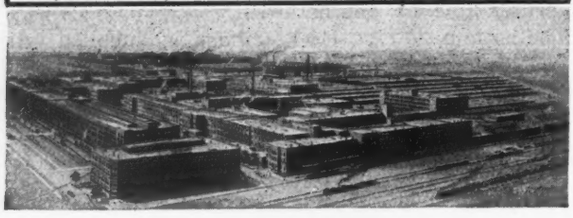
In the foregoing article we have discussed a simple method for recording armature winding data, a more comprehensive method of taking down these data, and a still more complete system for recording these data. The next article of this series will take up other methods used for tabulating winding data and will go into detail regarding methods that may be used for recording the data on special types of windings.

Fig. 7—For convenience in filing, the data taken on a number of the cards shown in Fig. 6 are consolidated on this card.

Type	Hp	Frame No.	Make	Style No.	Serial No.	No. of slots	No. of bars	Coil pitch AB	Lead pitch CF	Lead throw CD	Fig No.	Turns per coil	Size wire	Wires per bar
S	5	5	WH	35021	294641	49	97	1-12	1-50	1-16	II	4	#11	2
M	5	30-40	WH	8709	12469	71	142	1-17	1-72	1-21	VIII	1	1/2"x1/10"	2
K	5	10	WH	27069	134698	35	69	1-9	1-36	1-11	II	3	#13	4

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



G. A. VAN BRUNT
Managing Editor

F. E. GOODING
Associate Editor

D. H. BRAYMER
Consulting Editor

A. J. WHITCOMB
Associate Editor

Chicago, June, 1925

A Way to Get Recognition for Things You Do

IN THESE days initiative and originality, unselfishly applied, are the marks that distinguish the brand of ability that elevates to positions of authority and responsibility from the ordinary variety. Most companies watch for these signs among employes and have a way of finding larger and still larger places for the full growth and development of these evidences of future leadership in their organization.

Engineering societies have for years provided ways to extend recognition for worthy services and developopment work for the professions they represent. The American Institute of Electrical Engineers has its Edison medal, John Fritz medal, and Lamme medal. The American Society of Mechanical Engineers has its A. S. M. E. medal, the Holly medal and the Melville medal. The National Electric Light Association has its Coffin medal, and the Doherty medal and there are many other medals, prizes and scholarships, for the most part awarded to honor appropriately those who have accomplished a meritorious achievement in the arts and sciences.

Now comes announcement of four James H. McGraw medals for electrical men in three branches of electrical work: namely, the manufacturing branch, the jobbing branch and the contractor-dealer branch. These awards have three objectives:

(1) To give public recognition and reward for ideas which have been contributed to the common good by individuals in the electrical industry. (2) To give publicity to these ideas, that they may have wider application and employment. (3) To stimulate and encourage electrical men to think constructively for the broad improvement of the electrical industry and to carry through the ideas that occur to them.

To the electrical industry on the basis of its commercial subdivisions, this is the most extensive recognition of individual enterprise and achievement that has heretofore been set up and opened to men in all departments of the branches specified. Besides this, it sets up an annual test by which the thinking and accomplishment of today can be measured with that of yesterday in commercial progress on the same high plane of excellence of service to industry in any of its branches or as a whole as heretofore extended to engineers and scientists.

Through these awards we believe many discoveries of human intellects developed far beyond our expectations will be found year by year and their work brought forth to mark them as men devoted to a purpose and determined to elevate the electrical industry from a commercial standpoint to the high rank that it justly merits as a public service.

By these medals shall electrical men in commercial work be known. We hope that our readers who are eligible to compete for these awards will grasp this opportunity to gain recognition for the ability that in them lies.

Is the Slow-Speed Motor Coming Back?

THERE has been a definite trend toward the use of high-speed, induction motors for the roll drives in steel mills and other applications requiring a low speed. This has been brought about by the development of unusually efficient gears having a long life, and because the high-speed induction motor is much more efficient and has a better power factor than the low-speed induction motor.

Through the improvements made to the starting winding of the synchronous motor and also due to the use of improved magnetic clutches and other devices, the synchronous motor of today is able to develop much higher starting and pull-in torques than formerly. This has resulted in the application of synchronous motors to slow-speed drives on which it has been considered impossible to use such motors. In fact, one manufacturer is openly advocating the application of synchronous motors to certain steel mill, main roll drives. Steel mill, main roll drives are notorious for the starting torque required.

In deciding between the two types of drives certain factors must be considered such as over-all efficiency, maximum demand, power factor, ease of control, reliability, and relative cost.

What is going to be the outcome? Are we going to see a reversal in tendency from the use of high-speed induction motor units to the use of slow-speed, synchronous motors direct connected to the slow-speed machine? INDUSTRIAL ENGINEER would like to get the opinions of users and manufacturers on this question.

How Often Do You Have Your Meters Overhauled?

ONE of our readers who has had many years of experience in repairing and testing all kinds of electrical measuring instruments, recently made the following statement: "It is not unusual to find watt-hour meters which have been in constant use for several years in industrial plants and in all of that time they have received no attention whatever. If the users only knew what some of these neglected instruments may be costing them, they would realize that money spent for overhauling and calibration of their meters is well invested."

Recording instruments, and indicating instruments as well, go about their work quietly and perhaps it is only natural to assume, without thinking very much about it, that as long as the moving element rotates, or the needle indicates so many volts or amperes, everything is all right. Nevertheless, the fact is sometimes overlooked that the amount of power acting on the moving parts of meters is small and that any increase in the friction is certain to result in slowing the meter down. The oil in the bearings usually begins to deteriorate after a few months of service, so that its usefulness as a lubricant slowly decreases. Besides this, various other conditions, which are largely the result of natural wear and tear, tend to decrease the accuracy of a meter.

The watt-hour meter has been called the cash register of the electrical system and this comparison is an apt one. The sole purpose of this instrument is to measure a commodity which is produced, sold and paid for just like any other commodity. If it does not perform its functions properly, errors which may be costly when figured in dollars and cents, are very likely to result, although they may not be detected at once.

Failure to have these and other electrical measuring instruments overhauled and checked up at reasonably frequent intervals is an example of the kind of economy that carefully hoards pennies in one pocket and allows dollars to run out of a hole in some other pocket.

Don't Let Personal Feelings Handicap You

IN RECOUNTING some of his experiences, an engineer who has long been engaged in industrial plant work expressed some interesting opinions on the type of executives in a certain plant. Referring to a change which he had proposed in the building layout he said:

"This job came up a good many years ago and was an example of the laboriousness with which some folks will go around a post or column as though it were one of the pyramids. At the time, that job and a number of others aroused a bit of feeling which has only within recent years subsided to the extent of putting the principals on speaking terms. So long as I made a slight improvement here and there, my work was commendable enough. But when I proposed a major operation, such as changing the layout sponsored by someone in authority, then I was treated as though I were trying to take from religion its most helpful tenet. The change was eventually made, but only after persistent argument—and I had to handle the problem like a Richelieu."

This may well have been an extreme case of a certain attitude of mind which the necessity for doing things in the most efficient manner, in order to meet competition, has forced into the background. Nevertheless, most of us are inclined to feel that the ideas and schemes which we have worked out have much to recommend them, and we do not like to see them discarded or materially altered by someone else. Within limits this is a perfectly justifiable and proper way to feel about the work which we have done. If one does not have faith in his ideas and the work he is doing he will not go very far. For this reason it requires an unbiased mind, breadth of vision, and sometimes a good deal of moral courage to admit that someone else can, or has, improved on our work.

Before you give an adverse decision the next time you are called upon to approve plans which involve changes in some method, process, or whatnot, which you have worked out, ask yourself whether your decision is based on personal feelings or on sound engineering principles.

In business, engineering work, or any worth-while field of endeavor, there is no room for personal feelings or dislikes. Every proposition should be considered strictly on its merits. Anyone who attempts to handle a job on any other basis is putting himself under a heavy handicap and thereby seriously lessening his chances of real success.

Avoid Difficulties Instead of Overcoming Them

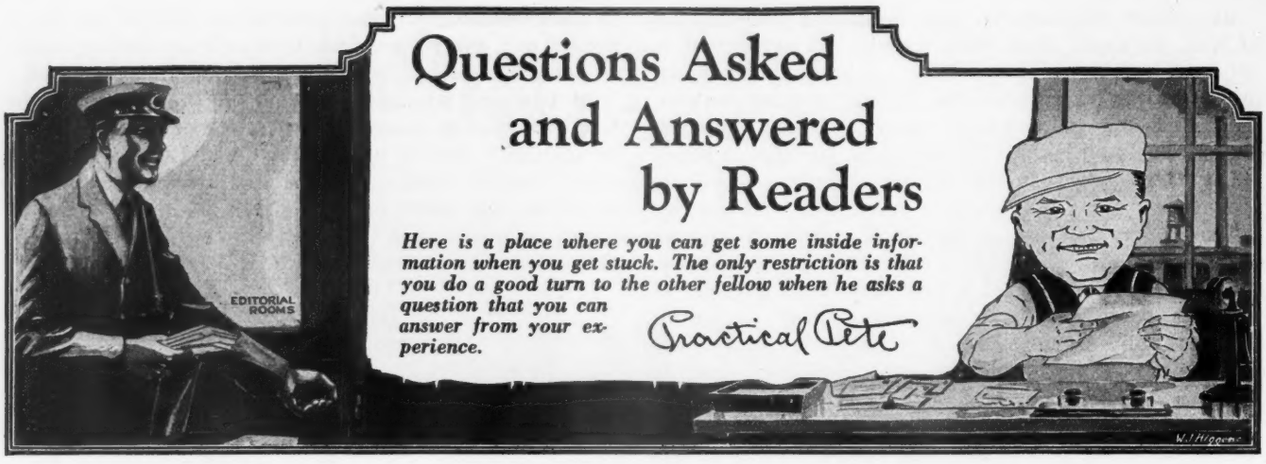
THE maintenance engineer is confronted continually with difficulties. Interruptions to operation in the path of power service, which may be due to breakdowns, or to any one of the multitude of causes which are responsible for service below par, are faced in his everyday work. His success or failure and the extent to which he keeps out of "hot water" depend upon how he meets these difficulties.

Some industrial men responsible for maintenance work have those under them handle each job as they come to it; these workers adjust a spring, tighten a bolt or belt, replace a worn or defective part or patch it up and rush on to answer another waiting call for help. In other words, they are handy men with their job always two or more jumps ahead of them. Such men solve each problem as it comes up, instead of trying to ascertain some of the whys and wherefores and prevent these problems from arising.

In impressive contrast is the work of a maintenance engineer's department which is largely free from this hustle and bustle. Of course, the unexpected happens and breakdowns or other interruptions of service do occur, but they are the exception rather than the rule. When the unexpected does happen, men who are able to diagnose the trouble and prescribe the most effective remedy are immediately dispatched to handle the job, because their ordinary work is not of an emergency character and they can leave it.

In such cases the question immediately arises, "How does the man responsible for maintenance work manage to keep everything going so smoothly?" The answer invariably is that he has studied his job; he knows what is the cause of each type of trouble and about how often it occurs. This knowledge has shown him where to direct attention before the trouble happens, and at the time when there will be the least interference with operation. His men, instead of spending their time rushing to clear up trouble that has happened, look for places where trouble inevitably will happen, and find the majority of them in advance. They can then choose the time most suitable for themselves and the production department, for making repairs.

How are these prospective difficulties located in advance? The methods vary in different plants but, in general, these involve regular and systematic inspections and overhauling by competent and experienced men who can recognize trouble when it is brewing and know what to do. This inspection routine is practically always backed up with records and reports which are analyzed frequently and made use of regularly. Practically any maintenance engineer can make use of this remedy.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Voltage Rating of Lamps Used for Synchronizing—In synchronizing two 440-volt alternators by using lamps in case the synchroscope should fail, what voltage rating of lamps should I use and how many of them? Should I provide lamps enough for 880 volts or 440 volts?
Indiana Harbor, Ind. A. R. D.

* * * *

Will Shorting Slip Rings Injure Motor?—Will short-circuiting the slip rings on a three-phase, wound-rotor, induction motor damage it? This is likely to happen when the external resistance is entirely cut out of the circuit so as to speed up the motor as much as possible. What takes place when one or more of the brushes do not make contact with the slip rings of such a motor?
Milwaukee, Wis. B. R. B.

* * * *

Calculation of Winding for Induction Motor—Will some reader please show me how to calculate the winding for a motor which has the following dimensions: Bore, 6 in.; outside diameter, 10 in.; slot depth, 1⅛ in.; axial length of core, 3⅞ in.; tooth width, 3/16 in.; number of slots, 36. I wish to have this motor operate at 220 volts, three phase, 600 r.p.m. What will be the horsepower of this motor, approximately?
Aurora, Ill. J. L. H.

* * * *

How Should a Delta-Connected Transformer Bank be Grounded?—I should like to know some of the standard or practical methods of grounding a delta-delta connected bank of transformers. We have a transformer bank consisting of three single-phase, 13,200/400-volt transformers, which are delta connected on both the high- and low-tension sides. Now I get a reading of about 100 volts from each 440-volt bus to ground. Consequently, I am planning to ground the low-tension side of the transformer bank. Can some reader tell me to what part of the low-tension delta I should connect my ground or what reactors or other devices I must use to obtain my ground connection?
Omaha, Neb. G. C. B.

* * * *

Strength of Brick Walls—We can find very little test data on the strength of brick walls with respect to forces acting against the wall horizontally and at right angles to the plane of the wall. If any readers have pulled down old brick walls they may be able to give me some data regarding the force required.

Suppose we have a brick wall three courses thick, 36 ft. high and 60 ft. long, with no openings and supported at each end by being tied to side walls of the same height and thickness. Assume that this wall has been standing for over a year and was constructed of No. 1 red brick and good mortar, well laid, with header courses placed in the standard manner.

What would be the approximate force required to pull this wall down, assuming the force to be applied at a point half-way up the wall and midway between the ends?
Bowmanville, Ont., Can. L. J. C.

* * * *

Operating Direct-Current Motor as Generator—We have a Century Electric, compound-wound, d. c. elevator motor rated at 220 volts, 52 amp., 1,200 r.p.m. which we wish to use as a generator to deliver 110 volts, 50-60 amp. I shall appreciate it if some reader will tell me whether it will be necessary to rewind or reconnect the armature, or if there is any way in which we can operate it as it is.
Caguanay, Que., Can. C. R.

* * * *

Winding Armatures With Asbestos-Covered Wire—I should like to get the experience of some of our readers as to the best methods of handling asbestos-covered wire when winding armature or field coils for mill-type and other heavy-duty motors. In what manner can I apply tension to the wire without mechanically injuring the asbestos insulation? What other kinks can you give me as to how I can best make up coils and wind armatures with wire having this kind of insulating covering.
Birmingham, Ala. L. A. C.

Answers Received To Questions Asked

Connecting Lineshaft Directly to Motor—We wish to connect a lineshaft approximately 100 ft. long directly to a 50-hp., 870-r.p.m. motor. The lineshaft can if necessary be supported from the ceiling, but we should prefer to mount it on top or at the side of heavy wooden or concrete posts. This department is on the ground floor and there is no basement underneath the building. I should like to know (1) if it is practicable to drive a lineshaft at this speed. (2) Would it be better to support the lineshaft on the top, or at the sides of the posts? (3) Is there likely to be excessive vibration? If so, how can it be overcome? (4) What kind of bearings should we use? Your advice will be greatly appreciated.
St. Louis, Mo. B. G. S.

Replying to B. G. S. in the April issue, I believe that you could make a very neat and efficient drive by connecting the lineshaft directly to the motor, by means of a flexible coupling, taking care to see that the lineshaft is properly aligned. The bearings should be spaced on short centers; then the chance of springing the shaft by the side pull of other shafts or machines will be small. The proposed speed of 870 r.p.m. is high, but many lineshafts will be found turning at that speed.

It would probably be better to support the lineshaft bearings on top of concrete posts or tapered piers. The piers should be of generous dimensions and well reinforced. Ball bearings should be used and should be mounted on an adjustable base or pillow block so that adjustments can be made in all directions. The bases of these bearings are made adjustable by the use of a combination of setscrews and wedges. The bearings are packed with soft grease and require very little attention after they are installed.

In our plant we have two drives similar to the one you have in mind excepting that they are shorter, being about 50 ft. in length. In both cases the shafts are driven at 900 r.p.m., and are standard shafting 3 1/16 in. in diameter, coupled directly to 100-hp. motors through solid flange couplings. This installation has been running for one and one-half years, 24 hr. a day, six days a week, and has never required any repairs. A few minor adjustments have been made, but the only charges that could be placed against repairs or maintenance is the cost of the grease for the bearings.

Special attention was paid to the installation of these drives; every part was accurately machined and carefully installed. SKF bearings are used on these two drives.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In the April issue B. G. S. asks whether it is practicable to drive a lineshaft at 870 r.p.m.

Driving a lineshaft at that speed is feasible, but much care must be exercised in its installation. First, he must limit the size of the pulleys (if made of cast iron) to 24 in. diameter, in order to keep the stress due to centrifugal force within the working strength of the material. Second, he must do a thorough job of balancing the pulleys because a slightly unbalanced condition will produce great vibration at that speed. Third, he must get a thorough job of alignment in order to reduce destructive "whipping."

The kind of bearing is immaterial. If there is a large starting-load, ball or roller bearings will be advantageous; sleeve bearings, however, will be entirely satisfactory. Whether to support the shafting on the top or sides of posts

depends on conditions. If placed on top, the posts must be braced below the bearings. Such bracing will detract from the appearance of the room, if it is not actually in the way. By securing the posts to the ceiling, the bearings can be bolted to the sides, with a minimum of construction work.

If the ceiling construction is capable of rigidly restraining the shafting, it would be best, from considerations of appearance and future layout, to place it there. Posts in buildings have caused me a lot of grief. Their interference with good layout is out of all proportion to their size and importance. I once replaced two building posts with a truss and succeeded in improving the equipment layout so that the working force was reduced by three men.

Los Angeles, Calif. C. O. SANDSTROM.

* * * *

Referring to B. G. S.'s questions in the April issue, (1) operating a lineshaft 100 ft. long at 870 r.p.m. is not practicable. Without knowing the service conditions, that is, the kind and type of machines that are to be driven from the lineshaft, it is difficult to say what the r.p.m. should be. For machine shop service 200 to 250 r.p.m. is desired; for woodworking shops 240 to 250 r.p.m. is used and for envelope machines, small printing machines and the like about 200 r.p.m. is being used.

(2) Supporting the shaft on top of the posts would be more desirable, using either the inverted shaft hanger or pedestal-type pillow blocks. Concrete posts with their foundations resting on good, hard sub-soil and independent of the building foundations, are practicable for such service. Mounting the bearings on the side of the posts is feasible, but more expensive and in some cases requires more maintenance.

(3) Vibration depends on the size of the shaft, its speed, distance between hangers, the number of driving pulleys between hangers, and the nature of the load or kind of machines driven. The spacing of hangers may be from 10 to 15 ft., and the load should be equally distributed near the hangers, with the light machines placed in the middle of the hangers. The motor should be placed in about the middle of the shaft so as to divide the torsion in the shaft. The heaviest load should be pulled near the motor, and the lighter load at the ends of the shaft. If certain machines are to be idle at times, it would be advisable to group them and divide the lineshaft into sections, with mechanical clutches or magnetic clutches to disengage the sections not in use. This arrangement has the advantage that should a breakdown or accident occur on some machine, that section can quickly be thrown out of service without holding up production on all machines.

A large diameter shaft, close spacing of hangers, and a lower speed than is stated in the question, will keep the vibration within safe limits.

(4) A roller bearing made in two halves or sections would be practicable and economical for this installation and would lower the cost of maintenance.

The motor could be arranged to drive the lineshaft by means of a silent chain drive which is economical, silent, positive and low in maintenance cost. Placing the motor on a platform or foundation elevated from the floor so as to have about 30- to 40-in. shaft centers is practicable. For this installation a 1¼-in. pitch by 5-in. wide, continuous-duty chain would be required. This would cost approximately $170.

Engineering Dept., E. H. LAABS.
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

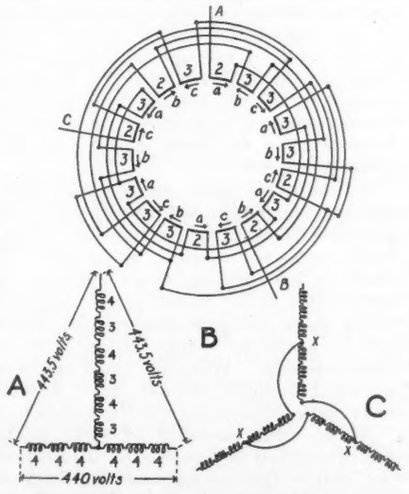
* * * *

Reconnecting Two-Phase Motor for Three-Phase Operation—I have a 10-hp., 440-volt, two-phase, squirrel-cage motor which has 48 slots and coils, six poles, and is series-connected. Can this motor be reconnected for three-phase operation by using the "T" connection? If so, how many coils must be cut out of circuit? What will the new grouping be for three phase and what horsepower will the motor develop after reconnection, if the speed remains the same as before? What is the smallest number of coils that can be reconnected from two-phase to three phase by the "T" connection?

Iola, Kan. G. E. G.

Answering G. E. G. in a late issue, *A* in the illustration shows the number of coils per pole for a six-pole winding T-connected for three-phase, approximately balanced voltage. The voltages shown are the phase voltages for actual balance. This diagram shows that three coils will be cut out of the phase making the T-connection. The grouping for one phase is the same as in the two-phase winding. The horsepower developed by this motor after reconnection, will, at the same temperature rating, be approximately 78 per cent of the nameplate rating. The number of coils remaining in the phase forming the T-connection, should be approximately 87 per cent of the coils in the two-phase winding. Any number of coils can be connected in this manner, but very few combinations will give much closer than 1 per cent voltage balance.

The connection diagram shown in *B* is one which I have frequently employed. This makes use of all coils, gives the exact voltage balance between phases and is within 3 per cent of the voltage of the nameplate rating. *C* is a schematic diagram corresponding to *B* and shows the coils per pole for a four-pole winding. The grouping for a six-pole winding will be as follows: 233-332-323-233-332-323. Care must be taken to start the phases so that the connection at *x* in diagram *C* will include in the delta section of the winding the same number of coils in each phase. The horsepower output with this winding will be approximately the same as for the T-connection.



Connections for changing two-phase motor for three-phase operation.

A, number of coils per pole in six-pole winding connected in T; *B*, connection diagram for changing from two phase to three phase, using all coils; *C*, schematic diagram of winding shown in *B*.

In both of these windings the size of the wire is the feature governing the output, up to the nameplate rating of the motor. CHARLES R. SUGG.

Atlantic Coast Line Railroad Co.,
Wilmington, N. C.

* * * *

Should Coils Be Purchased or Made in the Repair Shop?—We have in our plant about 1,000 motors ranging from 3 hp. to 100 hp. Roughly, one-third of these are older-type motors, while the remainder are of modern type. We have our repair shop, but so far have not attempted to wind our own coils. There is a feeling that we should do this, but before making any decision I should like to get the opinion of readers of INDUSTRIAL ENGINEER on the feasibility of doing this work. Will it pay us to do it? Can anyone give me some idea of the nature and approximate cost of the equipment needed?

I shall be very grateful for any information or suggestions you can give me.

Chicago, Ill. L. A. M.

With reference to the discussion in the March issue of L. A. M.'s question, I should like to add the following from our experience.

The same question came up several months ago in our plant. We have about 300 motors, mostly d. c. and a fair percentage of these are old style and so-called obsolete. It is hard to get factory-made coils for these old motors and the deliveries on same are bad. Our experience was the same as Mr. Housley's, with factory-made coils, which lay in stock. Some of them required considerable renovating before they were of use to us, when needed. Some months ago we borrowed a set of Browning equipment, from the local distributor, for test. We selected a 25-hp. crane armature, containing 35 coils, which was in the shop for repair, for our test. Our cost for the set of coils was just under $25. The manufacturer's quotation was $65. From information obtained from their service man, we found that the overhead was the sole difference. Using the same overhead as they do, our cost worked out approximately the same as their quoted price.

We find it unnecessary to stock any large amount of round wire larger than No. 30 in any standard insulation, nor any large quantity of any usual thickness of insulating papers or tapes. We can obtain these, on a few hours' notice, from the local representatives of the manufacturers.

We stock only flat and square wire and unusual insulating materials.

In addition to our loop winder, spreader and reel stand, we purchased shears. These are great labor and material savers. They are particularly useful for cutting wedges.

We built a brick, steam-heated oven, which will maintain a temperature of 240 deg. to 250 deg. F. We did not favor a gas-fired oven, due to the fire hazard inherent in the varnishes. We also built a dipping and impregnating outfit.

We conducted tests on varnishes and found that we could obtain a flexible varnish with high oil- and water-resisting characteristics. Therefore, we use but one grade of baking varnish. Our tests showed us, further, that the baking varnishes are incomparably superior to the air drying varieties. We are, therefore, dipping and baking everything that we can.

Last, but not least, I would add the warning: Don't skimp on quantity or quality of any insulating material. On the job mentioned wire, labor and overhead constituted better than 90 per cent of the cost. The balance was for sleeving, tape, varnish, etc. This being the case, the value of these items affect the cost of finished coils but little. However, the excellence of the insulation is the determining factor in how long the coils will last. In addition to the coil cost, we have the cost of installing the coils in the armature. If this be added to the cost of a set of coils, the percentage of the whole which is due to insulation becomes negligible.

G. R. HOFMANN.

Supt., Light, Heat & Power Dept.,
National Metal Molding Co.,
Ambridge, Pa.

* * * *

I was interested in L. A. M.'s question in a recent issue, because it is a much-discussed subject in plants that have a large number of motors. I believe that a plant that has as many as 250 motors should have the mechanics and equipment to do their own work, that is, winding and general repair, but I do not believe that this is a paying proposition in the smaller plants.

In his case there is no reason why his company could not easily install equipment and wind their own coils, because they already have a repair shop. I believe, however, that should they do this, it would be advisable to have an expert coil winder in charge of the various operations in making coils, as the coils are the heart of the machine and no winder can do a thorough job with imperfect coils. I would like to say in connection with this that very few armature winders are good coil makers and that coil making is a trade in itself.

The most expensive items in the list of coil winding equipment are the steam press for shaping, and the impregnating tanks. The ordinary dipping tanks could be built in your own shop of about No. 10 gage sheet iron. The winding machine and the spreading machine invented and patented by S. J. Browning and sold by the Mutual Foundry Co. of Atlanta, Ga., are one of the most up-to-date sets on the market. This company also sells wire racks and a spooling machine. Prices of this equipment can be obtained from either the manufacturers or Mr. Browning himself. Two or three taping machines would probably be necessary for a plant having the above number of motors. These taping machines may be bought from the Electric Service Supplies Co., Philadelphia, Pa.

A winding shop should have a lathe or a combination banding machine, as practically all d. c. machines and many a. c. machines have wire bands. Also, the commutators and slip rings should be turned in the shop under the shop foreman's supervision. Armature racks can be purchased or built in your own plant. They should be built individually to suit the winder or be adjustable in height, as an armature placed too high or too low is difficult to wind. For stators of the smaller sizes a table of heavy construction may be used; it is a good idea to have casters on the table legs. A bench well lighted and provided with drawers for tools is a real necessity.

Acmar, Ala. GRADY H. EMERSON.

* * * *

In reply to the question by L. A. M. in a recent issue, the situation should be analyzed in all its phases before assuming the responsibility of winding and treating coils in an effort to reduce the eventual cost. However, if any delay is being experienced in procuring factory coils, I would suggest that they be made in the repair shop.

With very little equipment one can make coils for small a. c. partially-closed slot machines, that for service will equal the factory coil. Serviceable formed coils for open-slot machines can also be easily made, but a little more equipment is required.

The nature and cost of this equipment are two of the factors which govern the quality and cost of the finished coil and should be determined after the quantity of coils to be manufactured has been carefully estimated. If that quantity is sufficient to justify the installation of a reasonable amount of equipment and the employment of labor for that particular purpose, there is no doubt that it is feasible to make your own coils, especially when it is realized that repairs can be made independently of any unforeseen delays in the delivery of coils from the manufacturer. Further, the first cost of the winding equipment should not be in excess of the investment involved in a stock of factory coils for even a part of the 1,000 motors.

On the other hand, many of the modern motors mentioned are likely to be wound with rectangular wire or ribbon, which are not always procurable on short notice; in such cases, round wire may have to be substituted. This is being done when necessary but much can be saved by using factory coils in these motors. Winding machines and adjustable forms which have proven very satisfactory are on the market.

Should the quantity of coils to be manufactured be considered insufficient to justify the investment required to install this special equipment, a lathe can be used, preferably with a hollow spindle, to facilitate the winding of loops beyond the lathe bed, as otherwise the lathe may not swing the larger forms. Many shops are using a worm drive mounted on a heavy table and driven by a 1-hp., d. c. motor controlled by a foot pedal. Tension on the wire may be secured by means of fibre or hardwood clamps.

I would not advise the expenditure of much time or money on an elaborate, adjustable form for winding loops for among the 1,000 motors no doubt many are identical and a good hardwood form is not difficult to make; after it is once used, it can be marked and stored away for future use.

A spreading machine should not be a necessity for the quantity of coils likely to be pulled out, although these machines do nice work and save time. A skilled winder can, with a little care, form at the bench coils that will be symmetrical enough for all practical purposes.

If it is desired to treat coils in baking varnish an oven will be a necessity, but it should not be expensive as it need not be large and can be electrically heated.

I would not recommend the manufacture of coils for 2,200-volt machines as they cannot be properly treated without more elaborate equipment.

Factory coils are a product developed by some of the best talent in the motor manufacturing industry and it has been my experience that with the exception of those for some small machines, they are everything that could be desired when winding a machine in an effort to reduce the chances of future trouble to a minimum.

San Francisco, Calif. W. O. HURLBUT.

* * * *

Answering the question by L. A. M. in a recent issue, he can make a substantial saving by winding coils in his own shop. In addition to the saving in the winding of the coils, better service will be obtained from your own shop. When coils are bought from an outside concern it often happens that there is a delay in getting them just when they are wanted. This, in turn, may delay the rewinding of a motor which may be very urgently needed.

The equipment required varies, depending upon the amount of work to be done. Some shops use a wooden form cut to the size and shape of a coil. A separate form must be used for each different size and shape of coil. A form which can be adjusted to wind different sizes and different shapes of coils can be made at small cost. This can be turned by hand or driven by a motor.

On page 19 of the December issue of INDUSTRIAL ENGINEER, a coil winding and forming machine, operated by a motor, is advertised by the Armature Coil Equipment Company, Cleveland, Ohio. I would suggest that L. A. M. write this company for further details and prices.

Muncie, Ind. GEORGE CROPPER.

* * * *

In answer to the inquiry by L. A. M. in a recent issue of INDUSTRIAL ENGINEER, we are glad to express our opinion, as it may help him to solve his problem.

In our opinion, a plant having 1,000 motors and located in Chicago can be better serviced by the repair trade than by a repair shop in the plant itself, equipped for rewinding. If such a fac-

tory were removed from an industrial center it would beyond a doubt be advisable to rewind the motors right in the factory, but in a place like Chicago there are 15 or 20 repair shops which are equipped to do this rewinding at any hour of the day or night and at prices which are probably below the cost of any shop located in the factory. Of course, these lowered costs are due to the large scale on which this rewinding is done in the modern repair shop.

The necessary equipment for rewinding would include winding and spreading machines which would represent an investment of $500 or $600, together with impregnating and baking equipment. The necessary stocks of magnet wire and insulating material would also tie up considerable money. Although we are in the magnet wire business and have a great deal of direct-driven equipment we do not do our own rewinding. G. B. FINCH.

Magnet Wire Dept.,
Belden Manufacturing Co.,
Chicago, Ill.

* * * *

In reply to L. A. M.'s question in a recent issue, I have worked in some plants where they did not make their own coils and in others where they did make them. It is my opinion that with the number of motors you have, it would pay you to make your own coils. I am sure that you will be able to realize a saving of at least 50 per cent over what you have to pay for factory coils. Also, your stock will be more flexible and the investment in spare coils will be reduced.

As to equipment needed, I would suggest that you investigate the new Master combined loop winder and coil spreader manufactured by the Armature Coil Equipment Company, Cleveland, Ohio. This machine is a big time saver, does accurate work and is substantially built. You will also want to investigate the taping machine made by this same company. As to other equipment, you will need a wire rack with tension blocks, baking oven, dipping tank for insulating varnish, etc. The total cost of this equipment should not exceed $1,000, including the setting up of the winding and taping machines which should have individual motor drive.

Chief City Electrician, H. J. ACHEE.
Woodward, Okla.

* * * *

Determining Size of Conductors for Intermittent-Rated Motors—Will some reader of INDUSTRIAL ENGINEER please give a method of computing the sizes of rubber-covered cables to be used for connecting intermittent-rated motors —particularly half-hour rated crane motors?

Montreal, Can. F. P.

Replying to the question by F. P. in a recent issue, the carrying capacity of wires has only one rating, and that is the rating which is allowed by the Underwriters. I would advise F. P. to consult a table of the current-carrying capacities of conductors and from it select a size of wire that will safely carry the maximum current which it will be called upon to handle, or that will have at least 110 per cent of the motor nameplate current rating. Some motors have intermittent ratings which permit the use of a motor that is smaller than would be necessary if the maximum load were carried continuously. This is not the case with conductors; their rating and size should be selected for maximum load.

Muncie, Ind. GEORGE CROPPER.

* * * *

Answering the question by F. P. in a late issue, the formula for computing the size of wires and cables, including rubber covered cable, is, C. M. $=L\times K\times C\div E$ drop.

In this formula *C. M.* represents the size of the conductor in circ. mils (1 mil=.001 in.). *L* is the length of the wire in feet. The length used should be double the length of feeder. *K* is a constant, which equals 10.8 ohms per mil-foot for copper wire. *C* equals current in amperes. The value of *C* in the case you mention should be 110 per cent of the nameplate current rating of the motor. (See Article 8, National Electrical Code, for percentage of nameplate current rating.) *E* drop represents the allowable voltage drop in the line, usually 2 per cent of the supply voltage in feeders.

This formula takes account of the *E* drop in the line; that is, a wire of the size obtained by the formula will carry the current without causing more than the allowable 2 per cent *E* drop, but it may not carry the current in accordance with Table 1, Article 6 of the 1923 National Electrical Code. The reason for this is that if a wire is short it may carry considerable current, causing only a small voltage drop; on the other hand, if the wire is long, even if carrying far less than its allowable current, it may cause an *E* drop much greater than the allowable 2 per cent. Because the formula takes account of *E* drop only one must always refer to Article 6, Table 1, after computing the size of the wire with the formula, and see that the allowable carrying capacities therein are not exceeded. This means, for example, that if the size of wire obtained were 26,000 circ. mil (the nearest size in the B. & S. gage is No. 6 or 26,250 cir. mil) and the current 65 amp., No. 4 wire would have to be used, if it is rubber covered. (See Article 6, Table 1, of the Code.)

In addition to the above, a conductor feeding one a. c. crane motor with a 30-min. rating must have an allowable carrying capacity of 110 per cent of the nameplate current rating of the motor. Thus, when referring to the table as above, 10 per cent must be added to the nameplate current of the motor.

When a. c. motors of the type requiring large starting current are started without the use of auto-starters, the starting current may be more than double the normal running current. The necessary current-carrying capacity of conductors in that part of the circuit supplying the motor, which is between the motor running protective device and the mains, will not exceed 300 per cent of the nameplate current of the motor. Motors rated from 0 to 30 amp. will require starting leads having a carrying capacity of not over 200 per cent of their nameplate current rating. Suppose you were computing the size of conductors feeding a motor having a full-load current of, say 50 amp.; the starting current would be not more than 100 amp. The conductors that must carry this starting current should have an allowable carrying capacity of 100 amp. After computing the size with the formula, refer to the table and see that the conductor to be used has an allowable carrying capacity of 200 per cent of the nameplate current of the motor.

In figuring the size of mains used to feed several d. c. motors, add together the full-load currents of all the motors and assume that the current in the mains will never exceed 60 to 75 per cent of this sum. This per cent is the demand factor and should be used as the value of *C* when figuring the size of mains.

To figure the size of a main serving several a. c. motors follow the same directions outlined above except that the demand factor should be larger. Where specific information is not available a demand factor of 80 per cent may be used. (See Croft's "Wiring for Light and Power," pages 73-74.) A larger demand factor should be used than in the case of d. c. motors, because of the large starting current required by a. c. motors.

To figure the size of conductors in two-phase circuits, first figure as single-phase; then take 50 per cent of the circ. mil obtained by the formula. Take the nearest size in B. & S. gage to the result obtained, referring to Article 6, Table 1, as to current-carrying capacity, as shown above. Figure the size of wire for three-phase circuits the same as for two-phase except that 58 per cent of the circ. mil obtained by the formula is used in place of 50 per cent.

Concord, Mass. DONALD FERGUSON.

* * * *

Replying to F. P. in a recent issue of INDUSTRIAL ENGINEER, if the motors in question are mounted on a crane it is usual to figure the capacity of the line contactor on the protective panel as being equal to, or greater than, one-half the sum of the full-load currents of all the motors. Furthermore, the contactor should be large enough to carry the full-load current of the largest motor continuously. The cables should then have the same current capacity as the contactor. For example, a crane may be equipped with a hoist motor, bridge propelling motor and trolley motor, all rated on a 30-min. basis and having full-load currents of 280, 150 and 50 amp., respectively, making a total of 480 amp.; one-half of this is 240 amp. The next larger size contactor is rated at 300 amp. and this rating should determine the size of the cables, because the largest motor draws less than 300 amp. If the largest motor is rated above 300 amp., this should be taken into consideration.

In regard to the wiring for individual motors, it is questionable whether any allowance should be made, due to the fact that the motors are rated on an intermittent basis, particularly in the case of induction motors. General Electric type MTC crane motors will in general stand 65 to 80 per cent of their rated full load continuously, depending on the size of the motor. MTC motors above 40-hp. rating will stand

80 per cent of their rated load continuously. It should be borne in mind that the maximum torque developed by an induction motor varies as the square of the applied voltage. This is approximately true whether the motor is at rest or running. For example, a drop of 10 per cent in voltage means that the maximum torque the motor can exert drops to 81 per cent of what it could develop at normal voltage. Since the current taken at starting is likely to be several times the full-load current of the motor, it is very important that the connecting cables be large enough so that there will be no undue loss in voltage in the cables. In case a crane hoist motor were called on to make an extra heavy lift, it is quite possible that loss of voltage in too small connecting cables would be so great as to prevent the motor from starting the load, which it would be able to do if full rated voltage could be brought to the motor terminals.

In the case of d. c. series crane motors, the torque exerted is not dependent on voltage, and a reduction in cable size due to the intermittent character of the load is not such a serious draw-back as in the case of induction motors. R. F. EMERSON.

Industrial Engineering Dept.
General Electric Co.,
Schenectady, N. Y.

* * * *

Number of Bars Covered by Brushes on Wave-wound D. C. Armatures—I should like to know why the brushes on a 4-circuit, wave-wound, d. c. armature cover only a little more than one segment, instead of two or more segments. I was, until recently, under the impression that the brushes had to cover as many segments as there are circuits per coil. If not, why have the four circuits?
Wichita, Kan. E. E. B.

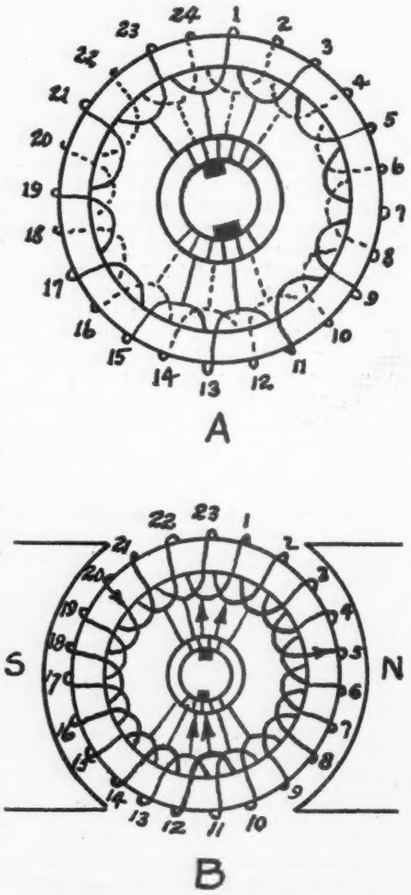
E. E. B.'s question in a late issue may be answered with the help of the accompanying diagram. For the sake of simplicity, two-pole, ring-wound armatures are shown at *A* and *B*. This illustration will be clearer than would a typical winding of the barrel type, that is, wave or lap wound, and does not depart from the problem since for any two-pole winding the number of independent brush sets must of necessity be two. In any case, the number of armature circuits in parallel is two so that our analogy is correct. If two identically wound machines are connected in parallel at their terminals, the combined current output will be double that of either machine alone. This same result can be obtained, with a consequent saving in material, by placing two independent windings upon the same armature core and subjecting them to the influence of the same field structure, as shown in *A*. Not only are the coil sides sandwiched together but the commutator segments connected to the independent windings are intermeshed as well. This is an example of a duplex winding built up as described of two separate simplex windings.

Any desired number of separate windings may be interleaved in this manner, but it will be noted that the intermeshing of the commutator segments requires the application of brushes whose width will be sufficient to collect the current from each pair of circuits at the neutral zone. Since simplex wave-wound armatures have two armature circuits in parallel irrespective of the number of poles, it follows that duplex wave windings will always have four parallel circuits or paths, independently of the number of poles.

The arrangement shown in *A* illustrates two entirely separate windings, each containing 12 elements, or 24 in all. Let us suppose now that one of the 24 elements is omitted and that the remaining 23 elements, uniformly spaced, are connected alternately as in *B*. We no longer have two independent windings each closed in itself as in *A*. There is now but a single closure. However, it will be noted that in passing from one brush to the other four paths in parallel are encountered, as in *A*. In short, both *A* and *B* illustrate duplex windings. The winding in *A* is known as a duplex, doubly-reentrant winding since on arriving at the starting point after tracing through the given connections, it is found that only half the total number of conductors has been encountered and it is necessary to trace through the remaining half at the end of which a second closure occurs. Winding *B* is a singly-reentrant duplex winding since all coils are traversed in reaching the first closure, although it is necessary to travel twice around the armature. In similar fashion, we could have a triplex, singly-reentrant wave winding, giving six circuits in parallel, and still properly commutated by a brush spread of not more than two segments.

From the above, the degree of reentrancy may be defined as the number of independent, separately-closed windings on the armature.

Engineering Dept., CECIL H. GREEN.
General Electric Co.,
Schenectady, N. Y.



Doubly-reentrant, duplex armature winding, A, and singly-reentrant duplex winding, B.

* * * *

Using A. C. Generator as Synchronous Motor—What changes, if any, are necessary in order to use a stationary-field, revolving-armature, a.c. generator as a synchronous motor? This is a Westinghouse generator, rated at 25 kva., 480 volts, 30 amp., three-phase 60 cycles, 1,800 r.p.m., serial No. 3212835. The exciter is direct-connected to the generator shaft and is rated at ¾ kw., 125 volts, 6 amp.

I should like to use this generator as a synchronous motor to drive a centrifugal sugar drier and to correct power factor. The power supply is 480 volts and all motors are rated 440 volts. If I can use this generator as planned, what horsepower will be developed and what will be the ampere input? Will I have to have an outside supply of direct current for excitation, or can I use the exciter on the machine?
Negros Occidental, P. I. A. C. M.

In reply to A. C. M.'s question in a recent issue, no changes will be necessary, providing the machine is equipped with a damper winding to be used in starting. An auto-transformer will be needed to impress a low starting voltage on the windings to prevent a sudden rush of current and the fields should be short-circuited until the machine is up to speed and thrown on the line. Then the fields should be thrown across the exciter, which will have built up its voltage by this time.

No outside supply of direct current will be necessary, as the exciter is used to excite the fields. If the machine has no damper winding, it may be brought up to speed as mentioned above, if it can be cut entirely free from its mechanical load, by relying on the eddy currents in the pole faces for its starting torque. This motor will operate successfully on 440 volts and if the mechanical load does not overload the motor electrically, the remaining energy may be used to correct power factor. The a. c. ampere input when the machine is used as a motor should not exceed its output as a generator.

As A. C. M. does not tell the power factor rating of this machine the horsepower cannot be accurately computed, but the following formula may help him.

For three-phase motors and generators, $I=\frac{W}{1.732\,E\times P.F.}=\frac{0.578\times W.}{E\times P.F.}$.

Where E=voltage, I=current per phase, $P.F.$=power factor, W=watts.

The value of W may be found from the formula: $W=1.732\times E\times I\times P.F.$

Alternating current generators and synchronous motors are rated either in kva. or kw., generally the former, and the power factor is usually specified on the nameplate. The capacity depends on the temperature rise, which in turn depends on the current flowing in the armature and field; therefore, neither term alone gives the true capacity. The safe load for a motor, expressed both in kva. and kw., is a

maximum when the power factor is unity. Field heating increases, and the maximum safe load both in kva. and kw. decreases with the power factor.

Service Engineer, G. B. HERON.
Westinghouse Electric & Mfg. Co.,
Columbus, Ohio.

* * * *

Locating Trouble in Power Circuits Run in Conduit—Can some reader tell me what is the usual method of testing for and locating short-circuits, grounds and so on in power circuits which are run in conduit, and from which branch circuits for motors and other equipment are taken off at intervals? I shall be very grateful for your suggestions and advice.
Pittsburgh, Pa. J. L. B.

Referring to the question by J. L. B. in a recent issue, I have found that trouble on conduit systems can be located, in most cases, by the use of a test lamp or a magneto test set. In using the test lamp, each branch is disconnected from the main circuit and the lamp tips are touched, one to the conduit where it has been cleaned and the other alternately to each of the feed wires. If the lamp lights it indicates that the trouble is still ahead of the tester, and this procedure can be followed until the branch on which the trouble occurs is disconnected; then the lamp will remain dark. When the trouble is not heavy enough to use the lamp test it is necessary to resort to the magneto test set.

Make sure that the circuit is dead and proceed as with the lamp test. If the bell rings it indicates trouble in the circuit under test; no bell indicates a clear circuit. Often the magneto is not advisable, especially in the testing of large power cables, as the capacity effect of the cable is often large enough to cause the test bell to ring when the line is really clear.

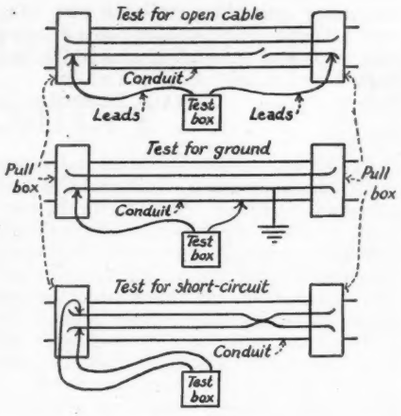
Goldfield, Nev. PHIL D. COMER.

* * * *

In answer to the question by J. L. B. in a late issue, several methods can be resorted to. Our susual method is to start at a point on the line in which trouble exists, say the main cutout or switch. We open the cable at the first branch cutout or pull box and test same out for breaks, short-circuits, grounds, etc., first by the use of a common battery-buzzer set. If no results are forthcoming we resort to a lampbank. When a cable is proved O. K. we repeat the test on the next section, etc., until the defective one is located. In case neither of these test sets prove effective we resort to a transformer to provide a selection of test voltages and currents as needed.

Continuing these tests from one outlet to another in the conduit run will show the cables either O. K. or defective and when the defective cable is found it can be repaired or replaced. It is good practice to test the entire line even after a defective part is located and repaired, thus assuring the elimination of possible additional defects.

In the diagram (only two cables are shown in conduit for simplicity) the methods for testing for short-circuits, breaks, and grounds are clearly shown. If the conduit run is long or should obstructions such as floors, walls, etc., be between two pull boxes the conduit can be used as one leg of the test circuit. However, it may prove ineffective, due to a poor or broken joint. I would advise that two wires of proven conductivity be used as test leads.



Methods of testing for defects in power circuits run in conduit.

NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

* * * *

Answering J. L. B. in a recent issue, I will endeavor to list some methods of testing power circuits that are run in conduit. These methods will probably aid him in testing for faults.

First open all switches, or otherwise disconnect all equipment and devices from the circuits to be tested. In some cases small equipment is connected to the line through fuses only; these fuses would have to be "pulled." After this is done, to test for a ground fasten one lead of magneto test set (commonly called "the mag") to the conduit and either hold the "mag" or insulate it from the floor or earth and touch the other lead to the individual conductors, while turning the crank. If one of the wires is grounded the bell will ring when the lead is touched to it. A lamp cut in series with a pair of leads will answer the same purpose if the ground is "dead" or the voltage of the circuit is low. For average testing a 16,000-ohm magneto is sufficient. For high-voltage testing, 6,600 volts and above, a 35,000- or 50,000-ohm magneto is better. In a test for short-circuits, tie one wire of the magneto to one of the conductors and touch all other conductors while turning magneto handle. It is a good idea to touch the magneto leads together before each test to be sure of good contact. Also be sure that the enamel is scraped off the conduit at the point of contact of the magneto leads. When testing oily conductors, such as transformer leads, wipe clean, as all oils are more or less insulators. In a test for short-circuits in long runs or where the conduit is run through floors, it is impracticable to have magneto leads long enough to reach from one end of the conductor to the other; so just ground the conductor, then test as if testing for a ground. When the right wire is found the bell will ring. Then the wire can be tagged at each end. In testing for open-circuits ground all wires in the conduit at one end and test all conductors at the other end as if testing for a ground. The conductors on which the magneto bell does not ring are open.

Of course, a battery and bell or buzzer can be used for the above tests, if desired, on low-voltage circuits. These are all reliable tests that are both simple and practical.

Acmar, Ala. GRADY H. EMERSON.

* * * *

Answering J. L. B. in a late issue, the usual method is to start at the beginning of a circuit, that, is at the main switch of the switchboard or supply point, and proceed from tap-off point to tap-off point, disconnecting each branch circuit and testing to ground or between conductors until the trouble has been localized in the main circuit or one of the branch circuits. It is assumed, of course, that the equipment connected to each branch circuit is disconnected during the test.

The foregoing method, while a sure one, is slow and tedious, as it requires the disconnection or cutting off of each branch circuit. A much more rapid method in the case of a ground is to send a direct current of 2 to 3 amp. through the circuit made up of the grounded conductor and the conduit itself. This direct current should be reversed about five times a minute. The reversing may be done with a double-pole, double-throw switch operated by hand, or by a commutator driven by a small motor. While the current is flowing the tester may proceed along the circuit with a pocket compass and hold it close to the conduit as he moves along, or apply it at intervals of 50 to 100 ft. So long as the ground point has not been passed, the compass needle will swing from side to side in time with the reversing field around the conduit. A strong field with the reversals timed to suit the compass will almost make the needle spin on its pivot. When the grounded point is passed, there will be no movement of the needle and the tester can retrace his steps and locate the point very closely, usually within a foot or two of the ground, if the ground is a good one.

In the case of a swinging ground or one due to vibration, it is, of course, more difficult to locate it. This method has the great advantage that it is not necessary to cut or disconnect the branch circuits. Testing outfits which can be used for this purpose may be purchased. These send a high-frequency current through the grounded conductor and conduits and by means of the tone in the telephone headset and exploring coil, both of which are supplied with the outfit, the tester may locate the grounded point in a manner similar to the compass method.

Short-circuits can be located by proceeding from point to point and cutting or disconnecting the branch circuit. The reversing direct-current method or high-frequency method may be used, however, to a certain extent if the conductors can be partially removed from the conduit at the branch-off points so as to allow a field from the conduit to affect the compass or exploring coil.

C. OTTO VON DANNENBERG.
Porter and Sanderson,
New York, N. Y.

In answer to the question asked by J. L. B. in a late issue, often it is not necessary to make a test to know that a short-circuit exists as, provided there are no grounds or overloads, short-circuits are indicated by fuses blowing or breakers tripping, and partial short-circuits by a creeping of the meter. Grounds may bring about the same results. Overloads may blow fuses or trip breakers.

To test for and locate short-circuits in power circuits installed in conduit a test lamp or testing magneto may be used. If a test lamp is used, first disconnect all branch circuits connected to the power circuit; then remove one fuse of the power circuit and connect the test lamp as the fuse was connected and note if the lamp burns. If it burns at full brilliancy there is a dead short-circuit in the circuit of which the lamp forms a part. If the lamp burns dimly there is a partial short-circuit, providing there are no grounds.

To test for short-circuits with a magneto, first disconnect the power circuit from all branch circuits; then open the service switch, or switch through which the power circuit receives its supply. After this, test out with a magneto. The ringing of the bell indicates a short-circuit.

To locate a short-circuit, disconnect at the panel boxes, in sections, the pair of wires which are short-circuited. How this disconnecting is done is explained in the following paragraphs on testing for and locating grounds. When the section containing the short-circuit has been located, provided it is in a section of conduit and not in cabinets or conduit fittings, remove the defective wire and pull in new wire.

To test for a ground a testing magneto is often used, or a test lamp may be employed when a testing magneto is not available. A test lamp, however, will not detect a ground of such high resistance as will a testing magneto. To test for and locate a ground on a power circuit with a magneto, first disconnect all branch circuits. This may be done by removing fuses through which the branch circuits receive their supply from the power circuit. Second, open service switch as when testing for short-circuits. Tests should first be made in the cabinet nearest the probable point of the ground. If this point is not known, begin at the panel box which is located at about the center of the power circuit and test by touching one lead of the test set to the box and the other to each conductor in turn. When the grounded conductor is found, disconnect it so that it will be in two sections. Now test, in the center panel box, the center of the section in which the ground is found, and disconnect as before.

Continue this process until the ground is located between two panel boxes. These tests have been made in panel boxes because in these boxes all the conductors are accessible without removing their insulation. The grounded conductor should be disconnected in a conduit fitting about midway between these panel boxes and tested each way as before. Finally the ground will be brought down to the conductor extending between two conduit fittings. If this short piece of wire still shows a ground it should be removed and a new piece pulled in.

Concord, Mass. DONALD FERGUSON.

* * * *

In answer to J. L. B. in a recent issue, when locating short-circuits and grounds in power circuits run in conduit it is of great advantage to have cutout boxes or busbar panels here and there along the lines. At these points the conductors can be parted, which helps to locate the trouble sought.

Then again, it is very necessary on a switchboard of any appreciable size, to have a ground detector voltmeter, or just plain ground lamps, so arranged that all feeders may be tested. The low glow of each lamp shows, of course, clear lines, but one extra bright lamp shows a ground. With the voltmeter and testing plug tests should be made often, at least once a day, on each leg of the system. When a switchboard is so equipped, a ground or short-circuit is not hard to find; it merely takes time. First, if a ground shows on the lamps or the meter, leave it there for a while; then when opportunity permits, as at noon, or after working hours, open first one and then another of the feeder switches for the various departments. Watch the detector and see what particular switch clears it off. This is the defective feeder circuit.

Close the switch, tag it, and allow the ground to show up again on the indicator. Then go along the line to the nearest busbar panel or cutouts and open all legs of the line; return and see if the ground is still showing on the detector. If so, the trouble is certainly between the switchboard and the first cutout or panel. If the ground fails to show, then this section of the line is OK., and the trouble is somewhere beyond it.

By the way, instead of returning to the switchboard to observe the detector each time a line is opened, a portable detector may be used, connected at the cutout or panel where the line is opened. This detector must be on the generator side, not on the far side.

This detector will indicate just as well as the one on the switchoard and may be made of one lamp, or a set of lamps, for each leg of the line; all these should be connected with a common return which is grounded to the conduit.

Make tests at first one cutout or busbar panel and then at the next, always connecting the portable ground detector on the generator side when the line is opened. Before long you will likely find a cutout which will still show the unbalanced ground lights when the line is opened. The trouble is between this point and the last place where the ground cleared off.

It is not a hard matter to locate such troubles, but it is often a very difficult job to pull out the conductor and draw in another. By the way, patching a bad spot with tape is not trustworthy, as it may ground again simply by pulling it in. The surest way is to draw in a new conductor; it is worth the price to get rid of the ground or short.

The writer has in this manner cleared off grounds showing up on the main switchboard when they were found to be simply a bare flexible lamp cord or two lying over an iron pipe at the far end of the plant.

In this case the portable detector showed its ground right out to the last cutout on the line; then there was nothing to do but to look over all the branch circuits. Such a stunt is not at all difficult; it merely takes time.

Jamestown, N. Y. H. S. RICH.

* * * *

In answer to J. L. B., in a recent issue, there are a number of ways of testing for grounds and short-circuits in power lines. I think that one of the quickest and most practical ways is to take out the fuses, both of which will probably be blown, of the main in which there is a short-circuit. These fuses should be replaced either by one fuse and a lamp or by two lamps. If the main carries 110 volts, a 110-volt lamp or lamps should be used. If the voltage is 220, a 220-volt lamp or two 110-volt lamps in series should be used, and so on according to the voltage of the main. If there is no other load on the line at the time of the test, the lamp or lamps will burn if a short-circuit exists.

The next step is to pull out the branch circuit switches, one at a time. As soon as the short-circuited branch is opened the light will go out.

Next, move the lamp up to one of the fuses of the branch circuit; then start at the middle and break the line. If the lamps go out, the short-circuit is beyond this break. Resolder the joints and move up to the next junction box and repeat the operation until the short-circuit is located.

If you are looking for a ground, make sure that the test lamp is in the grounded leg. I might mention here that when testing a lighting circuit by the lamp method, make sure that all lamps are out of their sockets or that the separate switches are open.

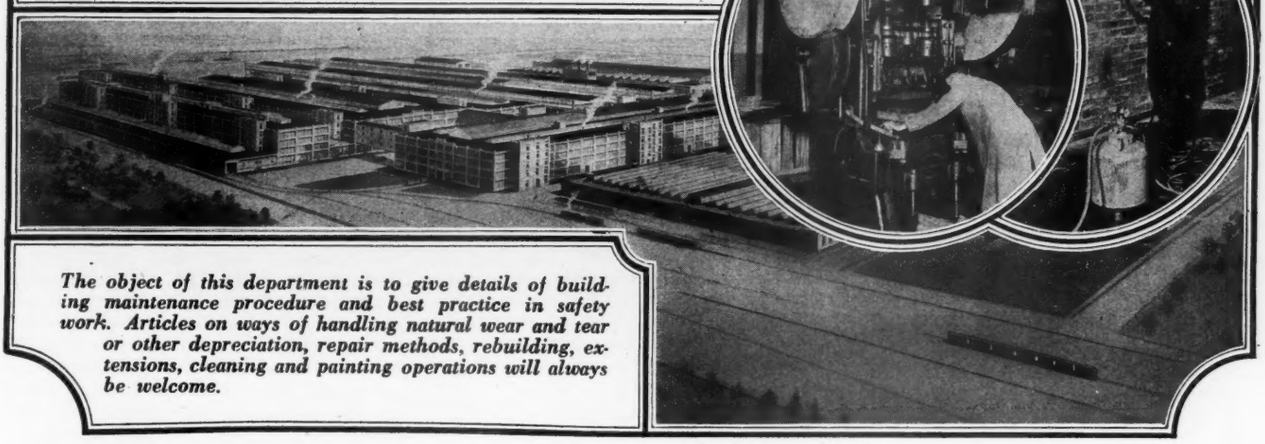
A testing magneto may also be used for locating trouble, but two men will be required. Personally, I do not like a magneto as it will often ring through when there is no ground, or at least no ground which is heavy enough to warrant taking out the wires. I had this experience on a 350-hp., 440-volt, 200-r.p.m. motor. The magneto indicated a ground, but the 440-volt test light would not light, nor could I get an arc when I touched the winding directly with the 440-volt lead without the lamps. This motor, which was a reversible and plugging type, was used on a coal hoist where it gets the roughest kind of treatment, but although this test was made eight or nine months ago, the motor is still running.

As to other methods of testing, there is the voltmeter method wherein by Ohm's law you can figure the resistance between one end of a grounded wire and the ground. This will give you an approximate idea of where to look for the ground, if you know the resistance of the wire per foot. There is also the Wheatstone bridge method.

NICHOLAS J. WEISS.

West New York, N. J.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

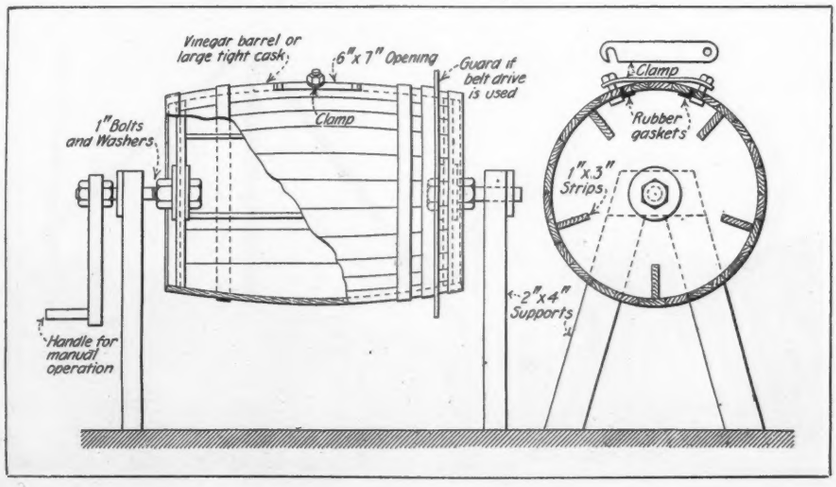
How to Make a Tumbling Drum Washer for Rags and Overalls

A SIMPLE washing machine, made from a vinegar barrel in a mounting upon which it can revolve, forms part of the equipment of a small shop and is used to wash out wiping rags as well as the greasy and dirt-laden clothes of the shop workmen. The simplicity and serviceability of this device are illustrated in the attached sketch, as being suitable for general use where time and the requirements make an inexpensive washer for heavy materials a feature worth adopting.

The first step in its construction is to open the barrel by removing a top hoop and one head. Large bolts, about 1 in. in diameter, are secured at the centers of each head, with washers on both faces, to form trunnions. Four or five strips of oak or other wood are fastened longitudinally inside the barrel as shown. These strips are made of 1-in. wood about 3-in. wide and, during the washing turn the clothes instead of permitting them to slide around. An opening about 6 in. by 7 in. is cut in the center of one side by cutting out a section of staves. This opening is used for inserting and removing the contents. The door is edged with rubber or some similar material to form a gasket and held with a small clamp.

A support frame is made from 2-in. by 4-in. planks to cradle the barrel on the bolt trunnions. This washing machine may be turned by hand if a handle is attached to one of the protruding bolts or it may be driven with a belt about the outer surface of the barrel. If a belt is used, a guide ring or plate is placed to prevent the belt from climbing the barrel. A flat pulley surface may be built up by using strips of old belt. The materials to be washed are placed in the barrel, which is then about half-filled with soap and hot water and revolved for half an hour. By that time the clothes are thoroughly cleaned of the heaviest dirt and grease. Where cleaning compounds are used it is well to see that they are not so strong as to damage the clothing.

Washington, D. C. G. A. LUERS.



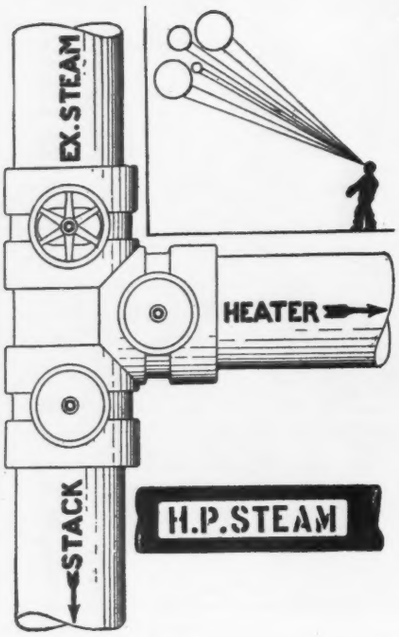
This shop washing machine may be easily constructed from an old barrel.

Standardized Identification Markings for Piping Systems

THE problem of devising some method of identifying pipe lines has been carefully studied by the Sub-Committee on "Identification Markings Other Than Color" under the sponsorship of the American Society of Mechanical Engineers and the National Safety Council. The first efforts of the committee were centered upon a combination of symbols or hieroglyphics along with a legend to designate the nature of the contained fluid or gas. This simple idea was discarded entirely because of the difficulty an operating force would encounter in recalling to mind the different shapes and forms of the symbols and their meanings, and the probable necessity for each industrial plant publishing its code.

It is recommended that the identification markings consist principally of a lettered legend, abbreviated or otherwise, which names the material carried in the pipe line. Where a knowledge of the direction of flow may be of service, it is suggested that arrows also be painted on the pipe. To make the marking more visible on pipe lines, which are located some distance above the normal line of the operator's vision, as shown in the upper right section of the accompanying sketch, the lettering should be placed below the horizontal center line of the pipe. Also, it is desirable where the view is unobstructed that the lettering be stenciled on the two lower quarters of the pipe coverings, rather than on one side only. Putting lettering on the under side will render it less liable to be obscured by dust collection or by mechanical damage of any nature.

In certain types of plants it may be desirable to label the pipes at junction points or points of distribution only, as is suggested by the accompanying sketch. In some power plants, the markings are repeated at intervals all



Suggestions on markings for identifying pipe lines.

The sketch in the upper right-hand corner shows how overhead pipe lines should be marked on the lower side so that they may be more easily seen from the floor and also not be obstructed by dust deposits. The large sketch shows a recommended stenciling for pipe lines. Generally, pipe coverings are white; however, on black coverings or black pipe, it is well to stencil a spot with aluminum paint and then stencil the identification marking over it.

along the pipe line. In any case, the operating man should decide the location and number of signs required in each particular system of piping.

Stencils of standard sizes are easily obtained from any stencil manufacturer. The letters of these range in height from ½ to 3½ in. For pipe smaller than ¾ in. in diameter, identifying marks are best made by the use of a metal tag with the letters prominently indicated by etching and filling in with enamel. The accompanying tabulation shows the suggested height of stenciled letters for different outside diameters of pipe or pipe covering.

Vehicles have been developed, which with aluminum powder, make a paste that will stand up under temperatures ranging from 700 to 900 deg. F. without loss of color or adherence. Black letters for dark coverings may be either painted or stenciled on a rectangular background of aluminum paint, as shown in the lower right-hand corner of the accompanying sketch.

Recommended Stencil Sizes for Marking Pipe Coverings

Outside Dia. of Pipe or Covering, Inches	Size of Stencil Letter, Inches	Outside Dia. of Pipe or Covering, Inches	Size of Stencil Letter, Inches
¾	½	5	1½
1	½	6	1¾
1¼	½	7	2
1½	¾	8	2½
2	¾	9	2½
2½	⅞	10	3
3	⅞	11	3
3½	1¼	12	3½
4	1¼	13 and over	3½
4½	1½		

How Installing a Yard Crane Overcame a Bad Loading Condition

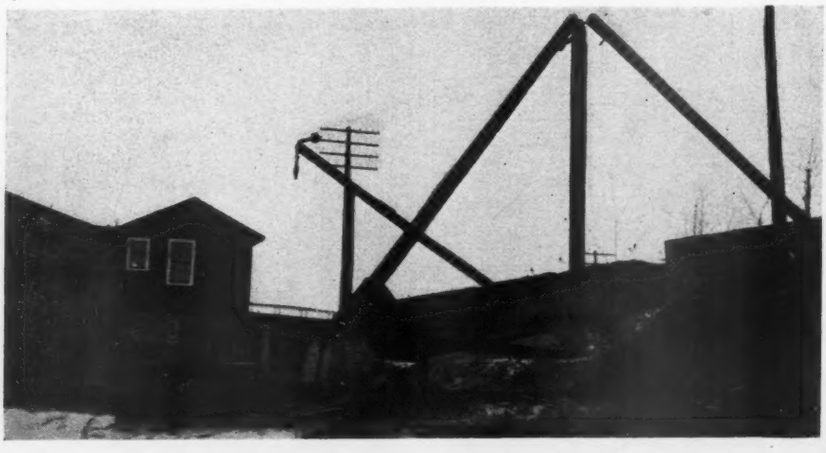
AT THE Bradney Machine Co.'s plant in Middletown, N. Y., the operating staff was confronted with a condition that seemed hard to overcome. The property had been purchased at a time when industrial buildings of any kind were at a premium. However, this one was ideal for the work of the new company, with the exception of loading and unloading cars on the adjoining siding. But a study of physical conditions showed the engineer that a yard crane could be used to handle this work to good advantage. Also it could be installed at no great expense. The cost of operation would be low, which was also an advantage in its favor.

The crane, as it was installed, is shown in the accompanying illustration. The 40-ft. boom swings through an arc of 180 deg., serves a storage yard for structural shapes and is used for loading the finished products on flat cars as well as for unloading. All shipments either way are handled through the local freight depot but incoming material, such as a carload of steel and outgoing fabricated products up to 10 tons in weight are placed on flat cars. To work this latter material up the hill to the track level and then hoist it 4 ft. higher ready to shove over on the car would cost as much as the profit on the work, if done by usual riggers' methods. Also, it would require the services of a number of men over a considerably longer period than it takes the crane to do it.

The crane is mounted on the bank, 2 ft. lower than the rails, 20 ft. from the center of the track, and a longer distance from the building, the shipping door of which is shown at the extreme left. A 2-ft. gage industrial track which runs out of that door parallels the structural storage ground and ends near the anchorage for one leg of the crane. Fabricated material for shipment from the shop is run outside on shop cars, picked up by the crane, hoisted and swung over on the cars—a distance of about 50 ft., and a difference in elevation of 14 ft. The cost of handling in this way is little more than if railroad cars ran directly into the building. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

This yard crane handles all heavy incoming and outgoing materials from cars to the shop, a distance of about 50 ft. and a difference in elevation of 14 ft.



One Method of Making a Close Seam When Laying Linoleum

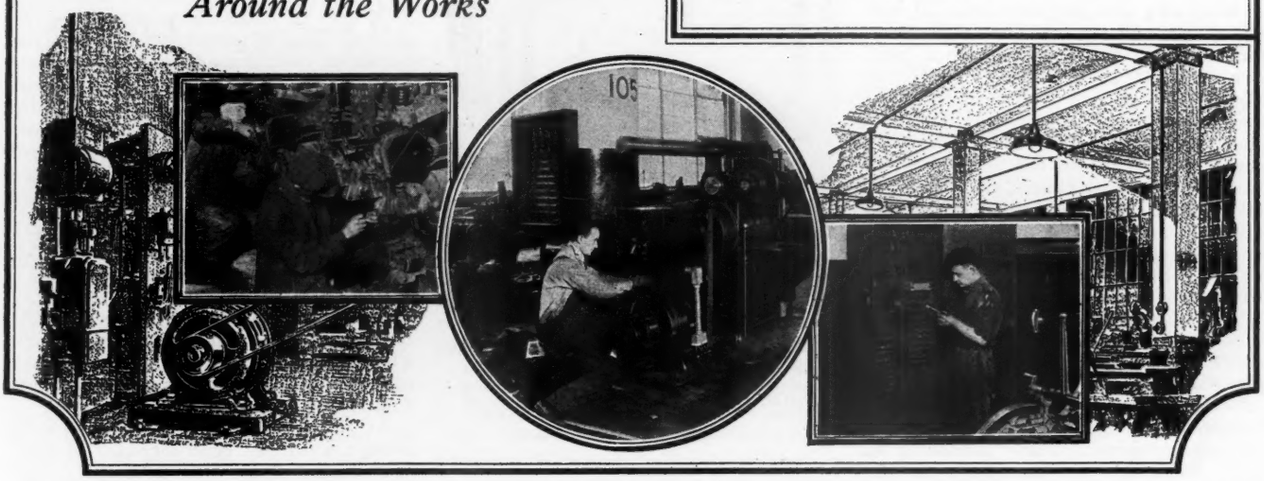
INDUSTRIAL maintenance men are frequently called upon to lay linoleum in offices and other sections of industrial plants. The durability of linoleum when placed where considerable traffic crosses the seams in the abutting strips is dependent, to a large extent, upon the care used to obtain an unbroken layer of this floor covering. When seams do not meet evenly and without gapping and also when one edge of the linoleum stands slightly above the other, the result is visible and rapid wear at the junction.

One method of making seams in linoleum and securing these seams to the floor so as to avoid the gap or upstanding edges, which was used by a carpenter in placing linoleum in an office building, is as follows: The first step was to overlap the edges of the linoleum and, with one edge as a guide, cut the adjacent strip to an exact fit. The edges of the linoleum were then turned back and the floor and the bottom edges of the linoleum were brush coated with a thick layer of spar varnish. After allowing this to dry for about 2 hr., the linoleum was pressed down to the floor and held by the tacky varnish. To keep the edges from rising a board was placed over the seam and ordinary building bricks placed on the board. The varnish was allowed to set for two days. The work was both neat and effective and the seam was almost invisible at the edges, as the varnish filled in the space between the two pieces.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



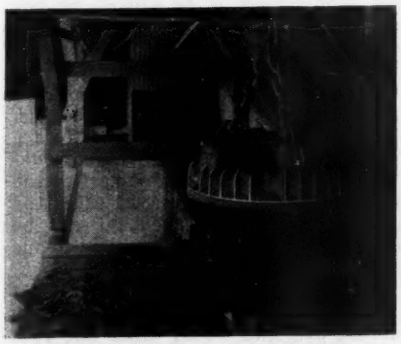
Magnet Removes Tramp Iron in Cement Mill

IN THE process used by the Security Cement & Lime Company of Hagerstown, Md., for making cement, limestone and cinders are crushed in hammer mills and mixed before being placed in kilns to be burned to clinker, after which the clinker is ground to form cement.

The raw material is put through three different crushing operations, so that if any scrap iron is present in the material, it is certain to do considerable damage to the crusher. To remove any scrap iron or steel that may be present in the cinders or limestone, lifting magnets are placed over the conveyor belt leading to the crusher, in the manner shown in the accompanying illustration. The magnets used are the regular No. 3 lifting magnets made by the Electric Controller & Manufacturing Company. They are suspended fairly close to the conveyor belt and any iron or steel in the material on the belt is attracted and held.

The cinders are bought from railroads and power companies around the country. These companies have no reason to be careful about guarding against the presence of scrap iron or steel. For that reason the magnet that hangs over the cinder conveyor soon picks up a motley collection of junk. Bolts, nuts, broken tools and the like are in the pile of iron that is cleaned off of the magnets every day. As the company quarries its own limestone, the workmen are more careful and less iron is picked out of it by the magnet suspended over the limestone conveyor.

E. F. Guth, the superintendent of the plant, states that the installation of these magnets over the conveyors has saved hundreds of dollars by preventing breakdowns of the crushers and consequent shutdown in the plant.



Lifting magnet suspended over conveyor belt removes scrap iron and steel in materials fed to hammer mill crusher in cement plant.

Portable Motor Testing Table and Motor Record System

I HAVE read with interest from time to time in INDUSTRIAL ENGINEER how operators have made motor tests while the motors are in service and have thought that others may be interested in knowing how our motors are tested and our records are kept.

The accompanying illustrations show several sample "Motor Data" cards which are used for all of our motors, numbering 172, of which 95 are fractional horsepower and 77 range from 1 hp. to 35 hp. Our data cards are indexed according to departments, so that a quick reference may be made.

Our single-phase motors are tested with a voltmeter and ammeter, while for testing the three-phase motors we have constructed a portable table, shown in the accompanying sketches and photograph. The table frame was made of maple and the top and shelf of cedar. It is equipped with three rubber-tired wheels to minimize vibration. A handle was made of ¾-in. pipe and fittings which also serve to hold the flexible connecting cable, while moving the table about. One end of a 6-wire, extra-flexible cable is attached to the terminal board and the other end is connected to three 60-amp., 600-volt empty fuse cartridges. The ferrules are drilled and tapped and the conductors attached with terminals. Adapters were secured which permit connections to be made at any of the 30-, 60- or 100-amp. safety switches at each motor or compensator.

On the test table Fig. 1, switches (A) and (B) transfer the voltage and current readings of the three phases. Switch (C) changes the current reading from direct reading to reading

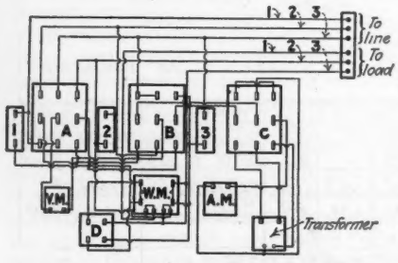


Fig. 1.—Circuit layout for testing table shown in Figs. 2 and 3.

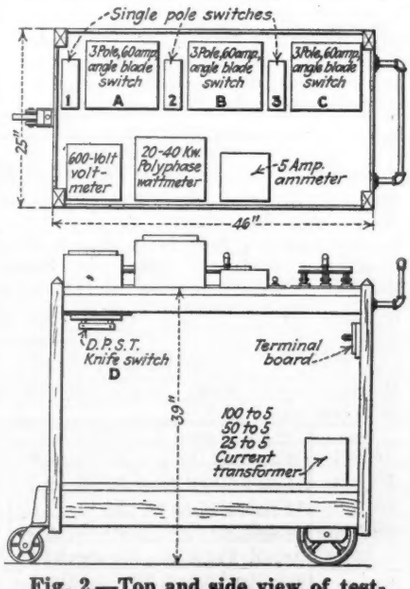


Fig. 2.—Top and side view of testing table showing construction and the equipment it carries.

with the transformer in circuit or vice versa. Switch (D) is used to short-circuit the current coils in the wattmeter. Switches (1), (2) and (3) are short-circuiting switches in the ammeter circuits.

With (A) and (B) forward, (2) and (3) closed and (1) open, the current in line (1) and the voltage across lines (1) and (2) is indicated. With (1) closed, (A) pushed backward, (B) remaining forward, (3) closed and (2) open, current in line (2) and voltage across lines (2) and (3) are indicated. With (1) and (2) closed, (A) forward, (B) backward, and (3) open, current in line (3) and voltage across lines (1) and (3) are indicated. Switches (1), (2) and (3) must always be kept closed when moving switches (A) or (B).

The efficiency and power factor ratings at various loads, as shown on the cards, are obtained from the motor manufacturer. As opportunity offers "no load" readings are taken and recorded on the test cards. These cards are arranged numerically according to motor number and are kept in the drawer with the "Motor Data" cards. Provision has been made for recording meter record numbers, etc., and it is expected that recording meters will be added to our equipment at some future date. The backs of the test cards have spaces for information regarding the mechanical end of the drive, but this is not used to any extent yet.

These motor data and test cards give all data needed on efficiency, power factor and load conditions, together with observations resulting from inspections.

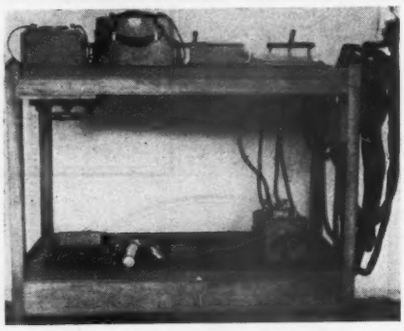


Fig. 3.—Testing table shown in drawings of Fig. 2.

The heavy flexible connecting cable is made up with six flexible conductors connected at one end to the terminal board of the table. The other six ends are connected to empty fuse cartridges. To support the weight of this cable a hook is provided at the fuse cartridge ends so that it can be hooked into the latch of the switch box of the motor being tested, taking the weight off both the connectors and fuse clips.

The card system has been in use less than a year, but already it has proved superior in several ways to our old method of keeping motor records in a book.

Chief Electrician, J. F. MORGAN.
Mercury Mills, Ltd.,
Hamilton, Ont., Canada.

MOTOR DATA

Card No. 1 Motor No. 1011
Make Gen Elec Co. U.S.A. Phase 1 H. P. 1/15
Location Hosiery looping Date 1917 Serial No. 1055700
Class Form 31 Size Frame No. Type 8a Style No. 2nd Wound
Rating hrs. °C. rise. Volts 110 Amperes 1.68 N.L.S 1500 F.L.S.
Efficiency | 50% | 75% | 100% | 125% | Power Factor | 50% | 75% | 100% | 125% | Watts at full load
Extras Inverted. 15" Cord.
Repairs July 22/24 new End Ring Assembly installed on rotor

~~COMPENSATOR~~
Make
Size Form Serial No.
Inspected
Repairs

A

MOTOR TEST CARD

Card No. 2 Date Oct 24, 1924 Motor No. 42
Make Can Gen Elec Phase 3 H. P. 15
Location Hosiery Full Fashioned Knitting + Ribbers Serial No. 30470
Class Form K Size Frame 10 Type I Style No.
Rating hrs. °C rise Volts 550 Amperes 16 N.L.S. 750 F.L.S. 720
Efficiency | 50% 84.6 | 75% 86 | 100% 86 | 125% 84.7 | Power Factor | 50% 79.5 | 75% 88 | 100% 92.2 | 125% 94.5 | Watts Full Load 13000
Extras Inverted Amperes No Load Watts No Load
Chart Feed inches per hour, minute. Chart No.
Motor:—oily, dirty, ~~clean~~. Air gap, front end, Top, .015" L. S. .025" R. S. .015" Bottom .015"
Oil in bearings O.K

Time	Volts x 1			Amps. x 5			Watts	H.P.	R.P.M.	Slip	P. F.	Mach. Operating	Input x Eff.—Output
9 20 A.M.	565	565	565	1.1	1.1	1.1	2100	2.81	750	0	39	Bursa Shuttle Only	281x846=248HP
9 25 A.M.	565	565	565	1.3	1.3	1.3	3500	4.7	748	—	55	All Sh. & Ribber	4.7x846=3.98HP
9 30 A.M.	565	565	565	1.5	1.5	1.5	5300	7.1	745	.6%	72	42% Ribber 35-83	7.1x846=6HP
9 35 AM	565	565	565	2.3	2.3	2.3	10000	13.4	740	1.3%	89	42% Ribber 134 58% Bursa 146	134x86=11.5HP
	100% Ribbers would take $\frac{(6-3.46)}{42}=\frac{302}{42}=4.8HP$												
	100% Bursa machines would take $\frac{(11.5-6)}{88}=\frac{55}{88}=6.2HP$												
	Total load on motor would be 6.2+4.8+3.98=14.98 HP												

B

A motor taking 110 amp. at full load, protected by 100-amp. fuses properly designed and correctly installed. Suppose the motor is overloaded and the current increased to 130 amp., which causes one of the fuses to blow. The motor continues to run single phase. Obviously, the other two fuses will have been heated almost to the fusing point and the only reason why they did not blow with the first fuse, is because it is impossible to get one fuse to blow at identically the same moment as another. However, on the blowing of the first fuse, the two fuses still remaining in circuit are subjected to a current 73 per cent greater than that which caused the blowing of the first fuse, or a total of 225 amp. A 100-amp. fuse, starting cold, will blow at 225 amp. in 7 sec., but having already been heated as mentioned, the 73 per cent increase of current will cause one or both of the remaining fuses to blow in a second or two. How then is the motor to continue to run single phase?

The argument might be raised that at the exact moment that the first fuse blew, the load was decreased to such an extent that the remaining two fuses would not blow. Such a decrease, however, would have to be almost 50 per cent. If the decrease in load were only one-quarter, there would still be a current of 169 amp. flowing, which would cause the blowing of one or both of the remaining fuses in a few seconds. In other words, to keep both of the remaining fuses in service, there would have to be a drop-off of one-half of the load in less than one second after the fuse blew—a coincidence that can be justifiably labelled a million-to-one shot.

The argument might be raised that a momentary overload or the starting current overload would cause one fuse to blow without blowing the other two fuses. A properly-designed and correctly-installed 100-amp. fuse will carry 120 amp. indefinitely. It will blow at 173 amp. in 21 sec., and yet it

Comment on "Single-Phase Operation of Polyphase Motors"

THE interesting article by Professors Warner and Hall on "Single Phase Operation of Polyphase Motors" in the April, 1925, issue, conveys an impression concerning the protection afforded by fuses on polyphase motors which is incorrect, although it is caused by what is left out, rather than by what is contained in the article.

As these writers point out, there is always a 73 per cent increase in current in the phase still connected after one fuse blows, whether it is a star- or delta-connected motor.

will not blow at a load of 275 amp. in less than 3 sec. This, in all ordinary cases, will take care of the starting current of the motor. Presuming, however, that the starting current is so great as to cause the blowing of one fuse, and realizing that the starting current lasts but a second or two, it is obvious that we would have to have a current of 300 amp. or more. All three fuses are, of course, subjected to this 300-amp. current. One of the fuses blows and at the instant of the blow, the other two fuses are subjected to a current 73 per cent greater, or a total of 519 amp., which would cause the blowing of one or both of these other fuses in less than 1/5 sec. Admitting that the starting current is dropping off at about that time, we cannot, however, get away from the fact that there is 73 per cent increase in current at the exact instant of the blowing of the first fuse and even though the load should be dropping off at that time, such a surge of current after the fuses had been heated up almost to the fusing point would cause the blowing of one or both of the other two fuses practically instantaneously. How then is the motor to continue to run single phase?

It might be argued that the motor is only 69 per cent loaded when one fuse blows. The 73 per cent increase in the remaining phase would give a current of 119.37 amp. which the other two fuses will continue to carry, but how is the first fuse to blow at 69 per cent of full load?

It might be said that motor burn-outs *do* take place because of single phasing of three-phase motors. This is admittedly true, but it is not true that such damage has ever resulted in motors protected by properly-designed and *correctly-installed* fuses. It will be found that whenever such damage has occurred, the fuse which first burned out did so because of poor contact, or in other words, because of heat caused by the resistance of a poor contact.

When fuses are incorrectly installed, that is to say, are subjected to poor contact, a 100-amp. fuse might blow at a load of 69 amp. The 73 per cent increase of current in the remaining phase would give a current of 119.37 amp. which would injure the motor, but would not blow the other two fuses if both of them were correctly installed and were not subjected to poor contact. It is in such cases as this last one that polyphase motors protected by fuses can be damaged, and in such cases only. A polyphase motor protected by properly designed fuses that are correctly installed is really protected. The fuses protecting any one motor should be all of one make and, of course, all of one size to insure such protection.

Poor contact on the fuse may be caused by: (1) poor contact of the fuse in the fuse block clips; (2) improper renewal of the fuse; (3) overloading of the fuse case; (4) loose lugs on the fuse block clips; (5) poor soldering of the connecting wire into the lugs.

All of these things can easily be guarded against in a well-run plant. They should always be guarded against whether fuses, circuit breakers or overload relays are used because the extraneous heating resulting is bound to give trouble no matter what kind of a device is used.

From all of this it is readily apparent that fuses of proper design, correctly installed, will not permit a polyphase motor to run single phase.

Chief Engineer, W. L. LODGE.
Bussman Manufacturing Co.,
St. Louis, Mo.

* * * *

I agree with Mr. Lodge in his statements that with fuses of uniform quality, correctly rated, and properly installed for a given motor, there will be very little danger of single-phase operation, but in actual practice we find that fuses are not uniform, have poor contacts, or are not properly installed and, of course, once in a great while there may be a defective fuse. His summary of fuse installation faults is particularly good.

There is, of course, a possibility of single-phase operation from a ground or single-phase short-circuit which might blow a fuse in a single wire. This ground might not be in the motor and might cause a fuse to blow which would affect several motors.

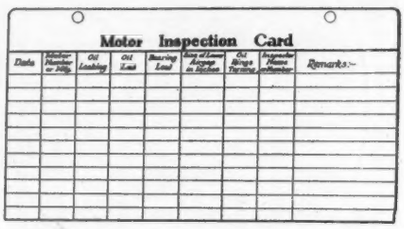
Badly unbalanced voltages are all too frequent. They cause a motor to take unequal line currents and in extreme cases one current might become great enough to blow a fuse while the current in the other lines was not great enough to do so. R. G. WARNER.
Electrical Engineering Department,
Yale University,
New Haven, Conn.

Proper Care of Motor Bearings Essential to Good Service

MANY industrial plants have learned by experience, and at considerable expense, the amount of trouble caused by worn bearings in rotating electrical machinery. In order to cause trouble, bearings need not be worn to such an extent that they allow the rotating element to rub on the stator or poles, as the case may be. Serious trouble has been caused in machines whose rotating element was still free to turn. For instance, if a d. c. generator is not equipped with equalizer connections in the armature winding, large cross currents will be set up in the armature when the bearings wear and allow it to come closer to the fields in the lower half of the frame, than to those in the upper half. This causes one-half of the armature winding to be overloaded, while the other half is underloaded, due to a higher voltage being generated in the lower half of the armature windings than in the upper half, and usually results in poor commutation, indicated by sparking.

The modern induction motor is built with a rather small air gap between the rotor and stator, as compared with the motors of eight or ten years ago. This change in design has been very welcome as the modern induction motor operates at a higher power factor and efficiency than its older brother. Consequently, we must watch the bearings in the up-to-date motor more closely than we did in the older one, for the bearings do not have to wear very much to cause rubbing and probably ruin the motor.

So far we have been considering the 2-bearing machine. In a 3-bearing motor-generator set we have three bearings to watch. Serious trouble has been experienced by some with a set of this kind, due to uneven wear in the bearings. For instance, the center bearing usually has a much larger bearing surface than the two outboard bearings and, therefore, seldom wears as fast. The outboard bearings may wear to such an extent that the rotating member is entirely supported by the center bearing. Each end of the shaft will then tend to "whip" and vibration accompanied by poor commutation is the result on the d. c. end, if there is a d. c. machine on the motor-generator set. It is an easy matter to overlook the bearings when trying to find the cause of this trouble, as the shaft may appear to be bent. Grinding the commutator aggravates the sparking, as flats are ground in it, due to the "whip."


Motor Inspection Card

Date	Number or Mfg.	Oil Leaking	Oil Lad	Bearing Lead	Amt. of Lower Airgap at Section	Oil Rings Turning	Armature Name or Number	Remarks:-

Here is a good form of report card covering inspection of bearings and air gaps on motors.

If a machine is allowed to run for any length of time in this condition it will, no doubt, wreck itself as the vibration will eventually break open the risers in the commutator, where the armature leads terminate, causing open circuits or at least high-resistance contacts. The sparking will grow worse until flashing occurs and the machine clears itself from the line by opening the breaker. Further operation without repair is then out of the question.

A system of inspection can be inaugurated in almost any plant, whereby each motor, generator, motor-generator set, or rotary converter is checked for bearing wear weekly or monthly, depending on the conditions.

The accompanying illustration shows an inspection card, which may be used by the motor inspector and kept on file in the chief electrician's office. This card may be modified to suit conditions.

Each inspection should be thorough and the lower air gap should be checked by means of a long feeler gage. In this way serious trouble may be avoided by installing new bearings when the inspection card indicates the necessity.

Machines equipped with ball bearings should be watched in much the same way as those equipped with sleeve bearings, as ball bearings will wear, need inspection, lubrication and cause the same trouble as sleeve bearings.

Always keep a good grade of oil at the proper level in all sleeve bearings, be sure that the oil is changed occasionally, that the oil wells are clean, and you will obtain high efficiency and long life from your bearings.

Service Engineer, GEORGE B. HERON.
Westinghouse Electric & Mfg. Co.,
Columbus, Ohio.

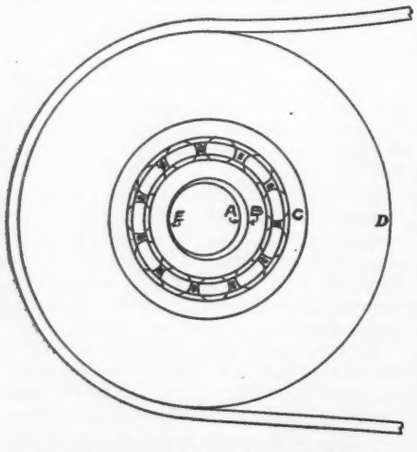
Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Comments on "Why Shafts Peen Under Inner Rings of Ball Bearings"

THE article which appeared under the above heading on page 253 of the May issue of INDUSTRIAL ENGINEER was very interesting. There are, however, some other points that might be mentioned and may be of interest to the readers of INDUSTRIAL ENGINEER.

The "shaft peening" mentioned is more correctly a rolling action. In the accompanying illustration the circle *A* represents the cylindrical shaft. Circle *B* represents the cylindrical inside bore of the inner race of the ball bearing. If the circle *B* is by mistake, made of very slightly greater diameter than *A*, there will be a line represented by *E* where the belt tension or reaction from meshing gears holds these two cylinders in contact. As the shaft rotates, this line moves around both circles *A* and *B*, but as the inner race of the bearing is much harder than the shaft, the surface metal on the shaft will be rolled away from its original position.



This sketch indicates how the shaft may be "peened" if the bore of the inner race is too large.

This action can be completely stopped by making the bore of the bearing slightly less than the shaft diameter, so that there will always be a slight press-fit.

Ball bearings of standard design are today manufactured to allow for the very slight expansion of the inner race that occurs from this press-fit. In this way, no cramping takes place in the bearing when mounted as outlined above.

In larger sizes of bearings, locknuts are added to hold the bearing in position lengthwise of the shaft. This method of mounting ball bearings is standard practice with practically all manufacturers of ball-bearing electric motors at the present time.

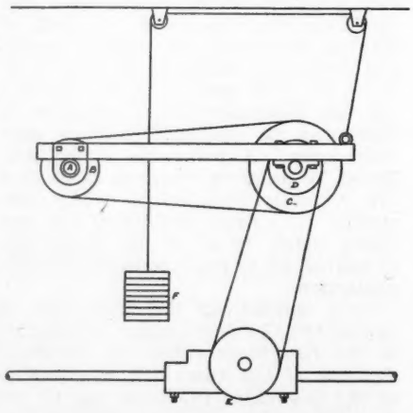
Engineering Dept., R. L. BROWN.
The New Departure Mfg. Co.,
Bristol, Conn.

Changing a Hand-Power Keysetting Machine to Power Drive

ANYONE who has had occasion to keyseat shafting with a portable, hand-power machine, knows that it is not an easy job. Some years ago the writer was on mill construction work and as there was no machine shop within 20 miles, it was proposed to do the keyseating of all shafting with a hand-power machine. The results of the first day were far from satisfactory and plainly showed that some means must be employed to speed up the work, else the shafting could not be installed according to schedule.

In order to speed up the work a swinging frame was devised, as shown in the diagram, and fitted with a jackshaft and pulleys. The handle of the keyseating machine was removed and a wood pulley substituted. The swing-frame was mounted at (B) by means of hollow trunions which surround the lineshaft. The stationary trunions were bolted to horizontal timbers which are not shown, for the sake of clearness. The pulley (B) on the lineshaft drives the large pulley (C) and also a loose pulley, not shown, on the jackshaft at the end of the swinging frame. The small flanged pulley (D) was mounted in an overhanging position on the jackshaft. The pulley (E) need not be flanged, although a flanged pulley might be more satisfactory.

The drive was so laid out that pulley (E) made 100 r.p.m. The milling cutters used on the machine were 2.5 in. in diameter. The counter weight (F) supplied the necessary tension to the belt-driven pulley (E). A snubbing device (not shown) was used to hold the counter weight up and to hold the jackshaft end of the swinging frame down while adjusting the machine on the shafting to be keyseated. When the machine was adjusted the belt was held on both pulleys while the counterweight was gently lowered. The belt from (B) to (C) was slid over from the loose pulley onto (C), thus starting the machine. Next, the vertical feed was turned down until the desired depth of cut was reached. The ver-



This swinging frame made it possible to change a hand-power keyseater for power drive and cut a standard ⅝-in. keyseat in shafting at the rate of 30 in. per hour.

tical feed screw was then locked in this position and the horizontal feed put into gear. This machine, when power driven, cuts 30 in. per hour of ⅝-in. standard keyseat. This is an increase of about 350 per cent over what a man will cut by hand in 1 hr. and, when an 8-hr. shift is considered, the increase is even greater and the operator is not tired.

During the keyseating operation the shafting was securely fastened down to trestles (bolted to the floor) by means of improvised cast-iron V-blocks and bolts with yokes across the top of the shaft. This was found sufficient to prevent the shaft from turning and the V-blocks on the machine prevented it from turning. This device did the work in an altogether satisfactory manner and was not in the least detrimental to the keyseating machine.

At another time, during repairs, several long keyseats had to be cut; so the handle was removed from a portable machine and a modified coupling made to fit an air motor installed in its place. This arrangement worked well for repairs in a plant where compressed air was available throughout the departments. A large electric drill could also be used to drive the machine and do satisfactory work.

Construction Engineer, W. L. STEVENS.
Smith Robinson Co.,
Vancouver, B. C.

Simple Stuffing Box Without a Packing Gland

THE usual method of constructing stuffing boxes is to make use of a separate gland whereby the packing is pushed lengthwise on the piston rod by screwing down on this gland.

On a pump shaft in a power plant an unusually ingenious departure from the ordinary stuffing box is a box with a single screw, which dispenses with the costly extra parts and avoids removal of the gland for repacking, as is shown in the illustration.

As will be seen, in place of the usual stuffing box, the cylinder head is drawn out into a long section of small diameter and a recess for the packing is grooved inside around the hole through which the rod passes. A drilled hole leads out from this and terminates in a threaded opening for a packing or setscrew.

Wick packing impregnated with tallow and graphite is fed endwise into this opening and encircles the shaft. The setscrew makes the packing tight by compressing it endwise. Segments of packing are placed under the screw as required to compensate for wear. This is a very simple means of keeping packing tight and in this installation has given as satisfactory results as could be wished for.

Washington, D. C. G. A. LUERS.

A Way to Reduce Accident Hazards on Power Transmission Equipment

POWER, no matter how controlled or applied, is still power. Machines and moving parts cannot be instantly stopped and consequently the worker of today is always exposed to the hazards of death or mutilation from the machinery and transmission equipment near which he works. Humanitarian motives generally prompt most employers to use every possible means of reducing working hazards to a minimum but even if this motive were disregarded entirely it is greatly to the employers' interest to eliminate every possible danger in order to avoid the losses incident to expensive lawsuits and interrupted production.

In the past few years much attention has been devoted to the protection of the worker by safety devices of various kinds, covering of exposed moving parts and automatic devices attached to saws, punch presses, drills and other such machines. Open transmission equipment, however, is still found in many plants and is an ever present menace to the lives and limbs of workers. It is to this particular phase of the subject that we shall confine our discussion in this article.

The necessity for transmission equipment is due to the fact that driven machines nearly always operate at a lower speed than the prime mover; therefore a means must be provided to step speeds down to the proper figure. Transmission equipment consists of those devices which are used to deliver power from the prime mover or source of power, to the driven machine. Comprised under this head are belts, pulleys, shafting, chains, sprockets, rope drives, open gearing of various kinds and enclosed speed reducers.

The hazards from open transmission equipment are obviously tremendous. Unguarded belts, pulleys, chains and open gearing traveling at high velocities and driven by power ranging, in some cases, as high as several hundred horsepower, present a menace to workers in the vicinity. When loose clothing, sleeves, belts or the hair of the worker come in contact with these unprotected moving parts serious accidents often result.

Much can be done to reduce hazards on transmission equipment by a careful study of each individual case considered from the standpoint of its potential possibilities for doing injury to workers. Every unprotected rotating part placed in a position where a worker may at some time or other get his fingers, hands, feet, hair or clothing near enough to be caught, is a permanent hazard. The one and only remedy is to cover, guard or enclose the moving parts. This can be done more easily and less expensively in some cases than in others. A simple screen or grating set before the parts will be suitable in some cases, but in others it is necessary to make special sheet metal or cast-iron guards to cover open gearing, moving pulleys, belts and other similar hazards.

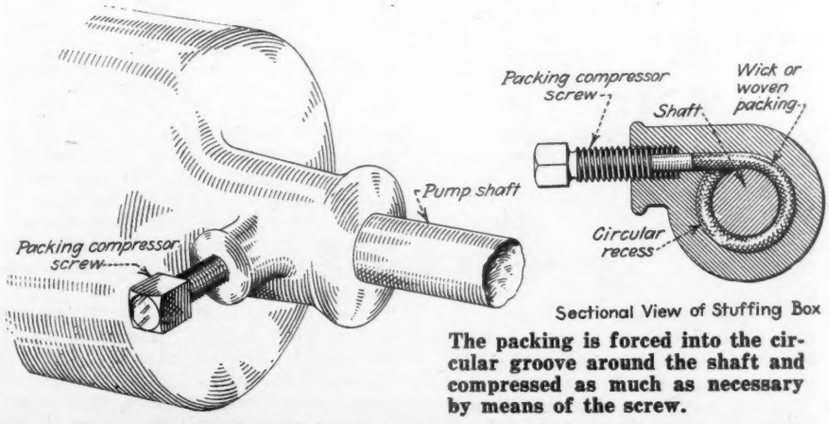
Many plants are using direct drives from motors to manufacturing machines, which eliminate much of the intervening transmission equipment otherwise required. This method is modern, safe and efficient. However, in many cases the speed at which the driven machine is operated is much lower than that at which the standard commercial motors can be secured or operated efficiently, and some kind of reduction unit is necessary.

One of the safest methods of transmitting power and obtaining speed reduction of the desired ratio is through the use of unit enclosed drives known as speed reducers. These machines are somewhat similar to the transmission of an automobile in that they consist of trains of gears enclosed in a suitable case or frame, but they differ in that they are designed to operate at a fixed ratio of reduction instead of a variable ratio as in the case of the automobile transmissions.

The frame resembles that of a motor. The gears are entirely enclosed, operate in oil and there are no exposed moving parts to endanger the workers. The reducing unit is so constructed that power is delivered to one end, called the high-speed end, by the prime mover and the desired speed reduction obtained through the various gears in the machine. The power is then delivered at the reduced speed to the slow-speed shaft which may or may not be concentric with the high-speed shaft. In installing a speed reducer it is only necessary to connect the high-speed shaft through a flexible coupling to the motor or other source of power and connect the low-speed shaft through another flexible coupling to the machine to be driven.

The reduction of hazards on transmission equipment is a subject worthy of the most serious consideration.

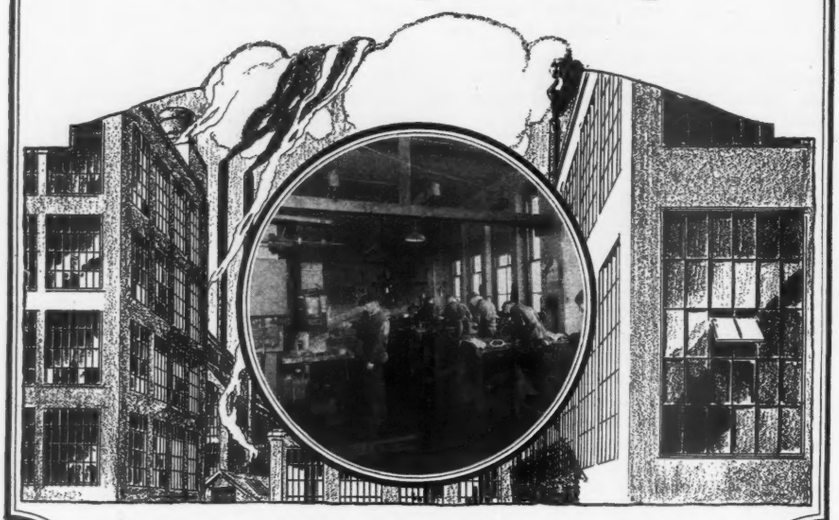
Chief Engineer, HARRY C. PETERSON.
Foote Bros. Gear & Machine Co.,
Chicago, Ill.



Sectional View of Stuffing Box

The packing is forced into the circular groove around the shaft and compressed as much as necessary by means of the screw.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Quick and Easy Way to Remove Cores of Fans

ON SOME small a. c. fan motors, it is sometimes necessary to remove the core and coils from the frame when making repairs. Many motors have the fan end bracket integral with the frame.

On those motors that have the bracket screws tapped into the core, if the other bracket is loosened and a wedge inserted between it and the frame, one on each side, the core will slide out with the bracket. This is about the only way it can be done quickly and easily on some small fan motors.

The lamp cord from the base of the motor sometimes burns off and in order to repair it efficiently it is necessary to remove the core, and here is where the above mentioned scheme comes in handy.

Of course this method does not apply to motors where the bracket screws are tapped into the frame.

I want to state that I have received much help and many ideas from INDUSTRIAL ENGINEER and if this scheme will be of assistance to other readers I shall be very much pleased. G. H. ENNIS.
The Electric Maintenance Co.,
Providence, R. I.

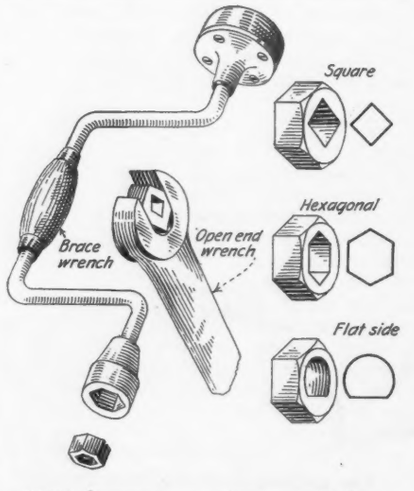
Easy Method of Making Special Sockets to Fit Odd-Size Nuts or Bolts

USUALLY it is difficult to obtain sockets for use in connection with small or odd-sized nuts and on bolts with special heads. The brace-handled socket wrench affords the desirable advantage of speed, as the socket is set over the bolt or nut and is turned continuously to remove or tighten without changing the wrench position on each part of the turn.

Special sockets, which can be used as slip sockets in either the solid or removable types of socket wrenches can easily be made from ordinary hexagonal nuts, as is shown in the illustration. This is a practical, time-saving kink which can be used to considerable advantage in almost any repair shop.

Obviously, the nut which is converted into any of the special sockets, should be sufficiently larger than the bolt head on which it is to fit to secure a wall of at least 3-16 in. of metal around the socket after it is machined or filed out to size and shape.

The slip socket may also be used with either the adjustable or open-end wrenches and will be found to protect the bolt head when the bolt is difficult to turn. G. A. LUERS.
Washington, D. C.



With several of these specially-slotted hexagonal nuts a socket wrench may be used on almost any shape or size of nut or bolt head.

Convenient Arrangement for Dipping and Baking Armatures

DIPPING and baking armatures is yielding handsome returns in the form of longer armature life, thereby causing less maintenance and fewer motor outages in many industrial plants and in electric railway systems. This process results in coating and impregnating the armature with a varnish that prevents loosening of the coils and consequent chafing. It also aids in resisting the attacks of oil and moisture on the insulation.

The possibility of pulverizing the insulation on the wires, brought about by vibration of the wires, one against another, or against a nearby coil, is eliminated by virtue of closing up all the space resulting from the drying out of the insulation used in the coil proper and that used as slot insulation when such is used.

The accompanying illustration shows the equipment used by the Harrisburg (Pa.) Railways for its dipping and baking process. A cylindrical tank is set in the floor as shown. This tank is deep enough, and of suitable diameter, to accommodate the largest armature that comes through the repair shop. In practice it is preferable that the inside diameter of the tank be about 12 in. greater than the diameter of the armature. Unless this distance is allowed, dipping a number of armatures in succession will cause a rapid and excessive evaporation of the varnish thinner, thereby resulting in a relatively heavy-bodied varnish requiring the addition of thinner.

When the tank is not in use a cover (not shown in the illustration) is placed over the top; the edge of the cover fits into a lip on the top edge of the tank. This lip is filled with transil oil, making an air-tight seal which greatly diminishes the evaporation of the varnish thinner. A pipe connects to the bottom of the tank so that the varnish may be pumped out when desired. A chain fall is suspended over the tank, as shown in the illustration, to handle the armature during the dipping process.

The procedure in dipping followed by this company is as follows:

An armature which is to be baked is first blown out with air and cleaned as much as possible. It is then mounted in lathe centers and given a benzine bath by turning it slowly in a trough containing benzine. This trough is fitted with a cover which thoroughly encloses the armature while it is in motion and confines the benzine and vapors to the tank. This cuts all the oil and grease that may have worked into the winding and loosens up and washes out the carbon dust and any particles of the old varnish that have cracked off, due to vibration and heat. The washing operation is considered essential because the presence of foreign matter in the form of oil, grease, or carbon dust in the varnish is detrimental. Mineral oil interferes with the drying of the varnish, and carbon dust tends to destroy its insulating qualities.

The armature is then placed in the

oven and baked so as to thoroughly dry out the winding. After this, the hot armature is dipped into Sterling baking varnish (Sterling Varnish Company, Pittsburgh, Pa.) by means of the chain fall suspended over the dipping tank, as shown in the illustration. The length of time the armature is left in the varnish, or the so-called soaking period, varies with the size and temperature of the armature and the condition of the varnish, and is roughly defined by the statement, "until the bubbling ceases." The armature is then lifted out of the varnish and allowed to drain for a length of time depending upon the size of the armature and the condition of the varnish. Thorough draining of the armature is desirable.

After the excess varnish has been drained off, the armature is placed on the small car shown in the illustration and the car is pushed into the oven. This oven (made by Despatch Manufacturing Company, Minneapolis, Minn.) is equipped with automatic temperature regulation and with electric heating elements that operate at black heat, which gives them a greater length of life than would be the case if they operated at higher temperatures.

An efficient baking oven cannot be constructed from a tight brick enclosure having a few resistors or other heating mediums. This is due to the fact that unless an oven is equipped with proper ventilation, the various functions of the oven during the drying process cannot be successfully carried out.

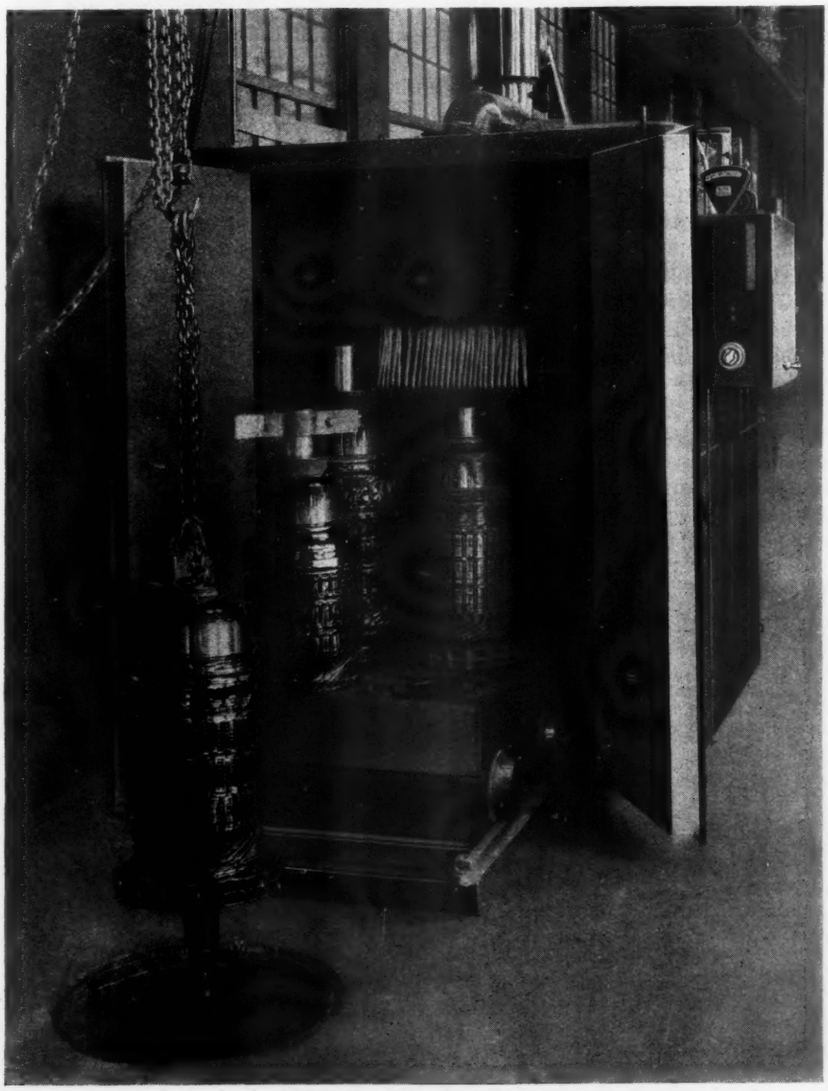
During the baking operation the varnish thinner, which is usually benzine, is driven off as a vapor which settles to the bottom of the oven. Some means of escape for this vapor must be provided in order to secure proper drying of the varnish. Since varnish dries by oxidation of the gums which form its base, after the evaporation of the thinner it is necessary that fresh air with its oxygen content come in contact with the armature in order to obtain proper drying.

During the drying out and the baking processes, it is essential that no part of the oven be at a much higher temperature than the remainder, for in this case there is a possibility of overheating part of the armature and burning the insulation. One of the methods used to prevent this in well-designed ovens is to set up convection currents of hot air so as to give a uniform temperature distribution throughout the oven.

Service Engineer, A. H. KOPPRASCH.
Electric Service Supplies Co.,
Chicago, Ill.

The dipping tank is placed immediately in front of the oven.

A chain fall located over the dipping tank provides a means of handling the armature during the dipping and draining process and also for placing the armature on the small car that carries it into the baking oven.



Laying Down Commutator Leads in Wave-Wound Armatures

MANY times when laying down the commutator leads in a wave-wound armature, trouble is experienced in not having very much room between the core and commutator to lay the wires symmetrically. In most cases, the reason for this is the cotton sleeve which is placed over each conductor for insulating purposes. It is readily seen that where there is only enough room for the conductors with the original covering, and a cotton sleeve is put on each wire also, there will be quite a bunch built up.

To eliminate this bunching, first lay down the wires coming from one of the slots, in the commutator at the proper span. Now, instead of laying down the wires coming from slot No. 2, or the next one to it, skip a slot and then lay those wires in, making sure that the proper number of bars on the commutator are skipped. Proceed this way (skipping a slot) until you have gone once around the armature. The wires laid in may then be bedded into place, taking care not to break the insulation in doing so. When the wires are bedded all right, the remaining wires can be laid down in the commutator. After doing this on a few armatures the winder will find that the first layer of wires will have taken but little space. With a little practice the space taken up by the bottom leads will be no more than two-thirds of that taken up when the leads are laid down symmetrically.

In very large armatures instead of just skipping one slot, skip two each time, bedding the wires as you go along. This will make a three-layer effect which will be of great advantage, for between each layer of wires a layer of 0.005-in. varnished cambric can be placed. This will reduce the danger of short-circuits caused by adjacent wires being jammed together while bedding them down. It also acts as a sponge to absorb the insulating varnish used in dipping and makes a perfectly solid mass, when baked.

Before laying down the top wires in the commutator, it is advisable to force or press a good insulating filling compound in the short space in back of the commutator where the wire insulation is thin. This will help to eliminate short-circuits due to dust particles, such as carbon dust and the light copper dust that is created when sandpapering a commutator.

In laying down the top leads the same procedure can be followed.

Electrical Dept., JAMES H. HANLEY,
Providence Gas Works,
Providence, R. I.

Removing Fumes, Gases and Vapors

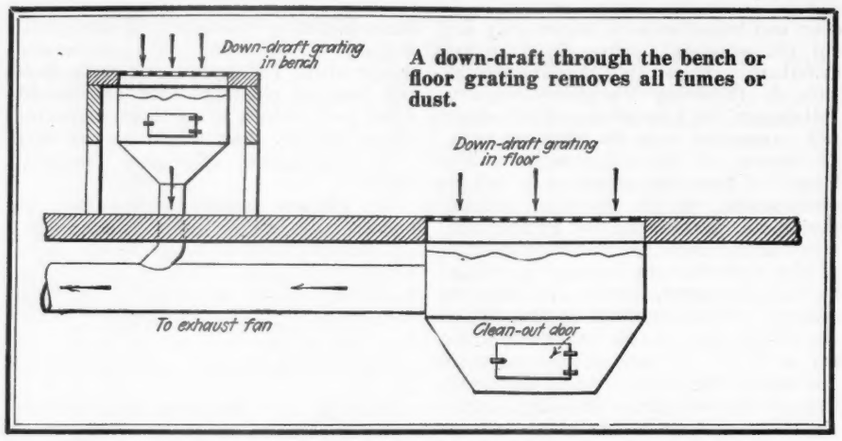
(*Continued from page 280*)

flow should be provided leading to suitably placed slots surrounding the source and connected with a strong suction. Where large storage batteries, for example, are used, one method of providing ventilation is to extend a slot across the front of the tank, just above the surface of the solution, with the other three sides surrounding the tank and raised somewhat to prevent the fumes overflowing anywhere except into the slot. In addition to this, it is usually necessary to provide a small amount of general ventilation at the floor level.

In a room where gasoline or other substances are used which give off fumes heavier than air and which are not easily collected at the source, the use of a system of strong downward ventilation is recommended in which air is admitted near the ceiling and withdrawn at the floor.

An arrangement for removing the fumes arising from articles which have been freshly painted, is to place them upon gratings set in the floor or bench top and connected with an exhaust fan, as shown in the accompanying sketch shown above. Generally, in painting industrial products with an air gun it is necessary to use, in addition, an enclosing hood or booth connected with an exhaust. The work to be painted is placed inside the hood and the vaporized paint or other coating drawn entirely away from the operator. Some of the accompanying illustrations show this type of work.

Foundries produce a mixture of heavy gases and light water vapor which must be disposed of. The most satisfactory method in cases of this kind, particularly with rooms having comparatively low ceilings, is to blow in fresh, warm air near the floor and along the outer wall, and exhaust it through floor registers at the center of the building. This will prevent the formation of fog by absorbing the moisture and carrying out the heavier gases which settle at the floor level. Monitors, where available, help to clear the upper portions of the building of the smoke and steam.



A down-draft through the bench or floor grating removes all fumes or dust.

A sufficient volume of air should be supplied to produce four or five changes per hour over a stratum 10 or 12 ft. deep over the entire floor in iron foundries and two or three times that amount in brass foundries.

Paper-machine rooms, dye-houses and the like require the removal of large quantities of moisture to prevent fogging of the atmosphere and dripping upon the product in process of manufacture, thereby bringing down rust or dirt which would damage the product. Where the vapor rises from large, open vats, which cannot be easily covered with hoods, probably the best method of removal is to provide ample, general room ventilation. A generous volume of warm, dry air (at about 70 deg. F.) supplied near the floor and exhausted at the ceiling will take care of most cases. The warm air absorbs the moisture, and as it becomes further heated by mixing with the air of the room, it naturally rises to the roof ventilator and passes out, often without the necessity of an exhaust fan. Some of the accompanying illustrations show a few types of roof ventilators. These work on the principle of an aspirator; that is, as the wind blows past or through the ventilator, it creates a suction which draws the air out of the room.

Propeller or disk fans are frequently placed in windows or wall openings, particularly in multi-story buildings where the vapor is generated several floors below the roof. Also, these same fans may be used in penthouses on the roof and connected to exhaust pipes which are carried down several floors. Where the fumes or vapors are particularly objectionable, or would stain the building it is best to either exhaust them on the roof where they will not blow back into or against the building, or into some kind of separator or washer. Frequently, these separators are placed ahead of the exhaust fan, so as to prevent suspended material clogging up the fan. This procedure is sometimes necessary in connection with ventilators attached

Another installation in which the heavy fumes are exhausted at the floor.

This photograph, like the one shown at the beginning of this article, was taken at the Deepwater Point Dye Works of E. I. du Pont de Nemours & Co. Here individual exhaust casings are placed around autoclaves and removable hoods are placed over the discharge valves and are exhausted through the rectangular ducts shown at the right and left top. Fresh air supply ducts are also placed above in the center.

to painting booths and in some chemical processes.

When the vapor is formed within a limited area, it is usually best to provide hoods connected with an exhaust fan, and thus prevent its escape into the room. These hoods are placed as close to the work as possible without interfering with the operations performed. In some cases the work is totally enclosed so that no fumes or gases can escape into the room. This, too, is usually done in connection with chemical processes, or where the fumes or products are inflammable or explosive.

Fans of the ordinary steel plate or multi-blade type are commonly used for handling fumes and vapor where the resistance to be overcome is low and the volume of air handled is comparatively large. Fans of this type are ordinarily designed to operate under static pressure (or suction) up to 5 in. of water which exceeds the requirements for practically all usual work of this kind.

If for any reason, greater resistances are to be overcome, high-pressure exhausters of special design may be employed which are capable of maintaining a suction of 10 or 12 in. of water at the fan inlet. The special feature of an exhauster of this kind is a narrow fanwheel operated at a high velocity. When the fan is to handle air containing acid fumes or other corrosive gases, it must be of special construction or otherwise protected to prevent injury. When the moisture does not contain a heavy proportion of corrosive fumes, it is often sufficient to paint the fan and casing with asphaltum or other protective material, but if the fumes are highly concentrated, it is often necessary to coat the exposed steel parts with lead or make them of copper, Monel metal, Duriron, Alcumite or other material not affected by the particular substance to be handled.

In some cases the problem consists in removing an objectionable odor. One example of this is the problem of providing fresh air for the offices of the meat packing companies at Chicago, Ill. Here the entire atmosphere for some distance from the office is contaminated by the fertilizer and some of the other by-products of this industry. The air contains both dust and an objectionable odor. The dust can be filtered out, but the odor still remains.

This problem is solved by sealing the double windows in the office buildings tightly, so that outside air cannot get in, and installing a forced air circulation system inside. The air is washed to remove the odor and dust, heated and circulated throughout the building, which is maintained at practically a constant temperature and humidity throughout the year. It is seldom necessary to go to these lengths. However, the subject of air washing will be taken up at greater length in the discussion of dust removal, as frequently, the dust in the air is more objectionable than the fumes, which are removed with the dust.

Other articles which will appear in later issues will discuss the removal of dust and also the removal or transference of heavier by-products, such as shavings, as well as light materials, such as cotton, wool and so on, which are also often moved pneumatically.

Rotary Operated as Condenser

(*Continued from page 264*)

leading, this commutating difficulty, even if serious, need not be allowed to prevent the desired use of the machine. In such a case, it is desirable to raise the running brushes to save brush friction losses and commutator wear. There is no need to leave these brushes in contact with the commutator, for no direct-current load is to be carried. All rotaries arranged for starting from the alterating-current side are equipped with brush-lifting devices which make this easy. The few (usually two) thin, pilot brushes which excite the field during starting will answer equally well for the same purpose during synchronous condenser operation. Their thinness greatly improves commutation and often eliminates the commutation difficulty. If even these starting brushes spark there is another alternative. If the rotary that is to be operated as a synchronous condenser is a spare, and another rotary is ordinarily in operation, it is usually a simple matter to arrange for exciting the spare rotary from the direct-current bus fed by the rotary that is in operation. Many switchboards are normally arranged for such bus excitation because it is the simplest manner of assuring correct direct-current polarity when paralleling a second machine with a machine in operation. Where bus excitation is not already installed, it is a simple matter to arrange for it by putting in a small knife switch. This makes it possible to raise all brushes, starting brushes included, and eliminate all commutation difficulty whatsoever.

How Service Conditions Affect Belts

(*Continued from page 270*)

less than with the tight side below because the sag of the loose side tends to become greater as the center distance is increased, thus reducing the arc of contact when the loose side is below and partly canceling the effect of the increased weight of belt between the pulleys. Therefore, the greatest difference in transmission capacity between operating the tight side above and operating it below occurs at the longest centers and gradually becomes less with short centers until at 4 ft. there is practically no difference in the power transmitted.

Careful examination of the data taken on pulleys of different diameters, revealed that the arc of contact does not seem to have as much effect on transmission capacity as the pulley diameter, and that the effect of reducing the size of one pulley is about the same as though both were reduced. Thus, a 12-in. pulley driving a 36-in. pulley will give about the same capacity as though it were driving another 12-in. pulley. It is likely that when one pulley is smaller than the other most of the slip takes place on this pulley instead of being divided between the two, thus increasing the co-efficient of friction between the belt and the small pulley, which tends to compensate for the loss in the arc of contact on this pulley. The diameter of the small pulley, or their common diameter if they are the same size, seems to be the determining factor in the power transmitted by the belt.

With this principle in mind, the curve in Fig. 8, marked "Small Pulley Size," was drawn. It takes care of the three factors, arc of contact, pulley diameter and pulley ratio and simplifies the computations, as compared with previously-used methods of allowing for these factors.

In addition, if the diameter of the smaller pulley is the determining factor, then for big drives the same thing should hold true. Thus, a 3-ft.

pulley driving an 18-ft. pulley should transmit the same power as though it were driving another 3-ft. pulley, or any size between 3 and 18 ft., at the same center distance. Data from these tests indicate that increasing the pulley diameters beyond 36 in. does not give much increase in capacity; so if both pulleys are larger than this the correction factor would be 1.00, leaving only center distance to be allowed for. The correction also becomes 1.00 for center distances over 25 ft., when the tight side is below, although there is probably some increase in capacity for greater center distances.

Slate as Switchboard Material

(*Continued from page 275*)

voltmeter; *Vx*, drop across the unknown resistance; and *Rv*, the resistance of the voltmeter in ohms.

In these equations *Rx* is the value sought. The resistance, *Rv*, of the voltmeter can be read from the instrument and is, therefore, known. *Vx* can be ascertained by subtracting from the e.m.f., *E*, impressed across the voltmeter and the unknown resistance in series, the voltage drop across the voltmeter. This gives us Vx=E—Vv. Then substituting this value for the *Vx* in the second equation, the resulting formula is Rx (in ohms)=Rv(E—Vv)÷Vv.

As an example, referring to Fig. 1 assume that:

E=Line voltage measured with connection indicated by dotted line =109 volts.

Vx=Voltage with dotted connection removed=1.3 volts.

Rv=Resistance of voltmeter= 20,000 ohms.

Rx=Resistance of insulation to be determined.

Substituting in the formula given above, Rx=20,000 (109—1.3)÷1.3= 1,656.91 ohms.

One method of determining whether any fault in the slate is due to dampness or a metallic conducting substance is to disconnect the busbar system from the individual switches and fuses and then test either from switch plate to switch plate or from switch plate to ground, using the voltmeter or high-voltage test. In this way spots which have a very low resistance can be located.

If leakage occurs only in individual circuits it is probable that metallic veins are present, whereas if the panel shows poor insulation all over it may be safely assumed that the slate has reabsorbed sufficient moisture to cause whatever leakage exists. By allowing sufficient time for the slate to dry, and providing proper ventilation this leakage usually stops.

In those cases where the slate is mounted in especially damp locations or directly against masonry walls, the exposed surface should have a coat of black marine finish as described previously, and the back should have a coat of any kind of varnish which will close the pores. These simple, inexpensive precautions should eliminate all leakage due to reabsorption of moisture.

Switchboard Materials Must Be Properly Installed

Upon the method of securing switchboard materials to the supporting framework or walls, rigidly fastened and ready for the electrical apparatus or machinery, depends in great measure the success of the entire installation. It is not enough merely to screw or bolt the various portions together; they must be so proportioned and arranged that constant use, varying temperatures and the shocks and vibrations incident to their use will not affect them. Furthermore, if installed in damp locations, or where there is a lack of circulation of air, the precautionary measures elsewhere described should be used. It has been found that most of the cases of trouble occurring after the apparatus is installed and in service are actually due to improper mounting of the panels, whether of slate or of other similar switchboard material, rather than to any other cause.

The very first step in the mounting of slate, is to make the diameter of the holes for the studs which are used to hold the panel in place from 15 per cent to 20 per cent larger than the diameter of the bolts themselves, as shown in Fig. 2.

Since it is practically impossible to make either a pipe framework with its malleable fittings or an angle-iron frame so accurate that all points of contact conform to a true plane surface, some means must be provided to compensate for these differences in order that neither the slate panel nor the framework will be distorted when the structure is tightened up. The best way to accomplish this, as is already a standard practice with most of the switchboard builders, is to insert between the back of the panel and the surface of the angle iron or the malleable pipe fittings a washer of suitable dimensions of some compressible material as rubber, fibre, leather or tough paper, as shown in Fig. 2 and some of the other illustrations.

The weight of the slate should not rest on the screws, bolts, cap screws or studs used for holding the slate in place on the framework. In the case of a complete switchboard assembly, a channel-iron base should be provided, such as shown in Fig. 3. A completely erected switchboard is shown in Fig. 4. If the switchboard assembly does not reach to the floor a piece of angle iron should be mounted on the framework on which the slate slabs rest.

When extreme conditions are encountered, in which the entire structure is subjected to a considerable amount of vibration, shock or jar, it might be of advantage to insert between either channel-iron or angle-iron base a strip of packing material such as ordinary rubber packing, in order to provide a cushion effect. With the weight of heavy busbar structures and the stresses caused by oil circuit breakers or compensators careful cushioning of the entire switchboard will greatly reduce destructive vibration upon the highly sensitive meters mounted on the board. This precaution will also prolong to quite an extent the life of these expensive and essential instruments.

It will also be found of advantage to allow plenty of clearance in the holes drilled for switch or circuit breaker studs to be used in the mounting of any other instrument or apparatus. It will result in ease of alignment and less cost for mounting, will prevent stresses that may fracture parts of the panel and at the same time reduce the destructive thermal action of momentary overloads on any particular circuit.

Good circuit breakers or good knife switches have been known to be spoiled before being actually brought into operation by forcing them into holes spaced so that they would bind the parts, throwing them out of alignment and thereby preventing proper operation. The same applies also in the mounting of electrical instruments. In the case of starting compensators, oil switches, and circuit breakers, the slate will be able to withstand vibration and

impacts much better if the studs have plenty of clearance, as thereby either the washer or the contact surface of the apparatus will evenly distribute the pressure.

The U. S. Navy specifications are severe in regard to the mounting of switchboard materials. They were primarily designed to protect the board against the terrific shock of modern gunfire. These specifications give a most excellent method for protecting installations exposed to severe vibration, shocks or jars, and are recommended by many authorities for that purpose. Extracts of the essential portion are as follows:

Panels shall be secured to an approved frame of angle iron. Two thicknesses of ⅛-in. rubber packing shall be inserted between the bottom of panels and the horizontal angle-iron support, and one thickness of similar packing shall be inserted between back of panels and vertical members of frame.

Switchboards shall be mounted on frames of angle iron having dimensions not less than 2¼ in. by 1½ in. by ⅜ in.

The importance of properly providing for the mounting of slate and for the assembling of the angle iron or pipe framework should be strongly emphasized. The construction of the framework is, therefore, of especial interest. Some of the accompanying illustrations show three different types of assembly. For example, in Fig. 5 is shown an angle-iron switchboard frame; in Fig. 6*A* a benchboard frame; and in Fig. 6*B* a pipe frame switchboard assembly. Each of these is typical of good construction and shows suggested methods which may safely be followed.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Insulation Resistance Testing Apparatus—Catalog 1075, entitled "Megger and Bridge-Megger Testing Sets," not only describes the apparatus but gives a discussion on insulation and the measurement of its resistance. In addition, several pages are devoted to general directions for using these testing sets. This is followed by special directions for various insulation resistance tests, and for megger testing.—James B. Biddle, 1211-1213 Arch St., Philadelphia, Pa.

Junction Box Condulets—Folder 21 shows three types of junction box condulets with removable hub plate which provides for additions without disturbing the existing conduits or interrupting the service.—Crouse-Hinds Co., Syracuse, N. Y.

Spur Gears—A folder bearing the title "Gear Teeth That Are Accurate" describes the advantages of using heat-treated spur gears with ground teeth and indicates the sizes in which they may be purchased.—Foote Bros. Gear & Machine Co., 236-246 N. Curtis St., Chicago, Ill.

Belt Fasteners—Catalog 717 describes the line of Bristol patent steel belt lacing which consists of steel prongs with wedge-shaped points, similar to staples. These points are driven across the joint of the belt and the points clinched. This catalog lists the various sizes of steel lacings and shows the sizes of belts to be used with each. Patent steel belt plates are likewise listed, together with the sizes of belt they are to be used on. Space is also given to wire belt lacing, belt hooks and also to a special safety set screw.—The Bristol Co., Waterbury, Conn.

Enclosed Fuses, Fuse Cut-Out Bases and Fuse Boxes—Catalog 60 entitled "Noark Enclosed Fuses" devotes 64 pages to a discussion, description, specifications and prices of the "Noark" renewable and non-renewable fuses with ferrule or knife blade contact, as well as special types, non-indicating fuses, high-tension fuses, service and subway junction boxes and other protective devices.—The Johns-Pratt Co., Hartford, Conn.

Combined Megohmeter and Voltmeter—Bulletin 135 describes the portable "2 in 1" megohmeter which indicates both resistance and voltage and may be used to measure the insulation resistance of electrical equipment during and after the process of manufacture or assembly.—Herman H. Sticht & Co., 21 Park Row, New York City.

Electric Heat—A bulletin bearing the above title is issued frequently by the Department of Publicity of this company, and shows a variety of applications of electric heat in industrial plants. This will be mailed regularly upon request.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Flexible Couplings—Bulletin 37 describes the Franks flexible coupling which consists of flanges connected by flexible pins. This booklet shows a large number of installations, gives dimensions of units of different capacities, directions for installing, information for users, and several pages of information about direct-connected installations. This equipment is made in heavy-duty, high-speed, marine and various special types as well as a light pressed-steel unit for fractional horsepower motors.—Smith & Serrell, 26 Washington Place, Newark, N. J.

Copper Covered Steel Wire—A binder of engineering data shows the method of making the copper weld by the molten welding process and also contains a number of sheets giving engineering data, specifications for purchasing, inspection and testing as well as charts and tables. This information covers solid and stranded bond wires, ground rods, guy, messenger and strand wire, police and fire alarm circuits, signal and telephone line wires, overhead ground lines, sag and tension charts, wire and loading tables, as well as general and comparative wire tables, and so on.—Copperweld Steel Co., Braddock Post Office, Rankin, Pa.

Electrical Porcelain—A folder illustrates, prices and describes Federal solid, telephone, nail and split knobs as well as cleats and porcelain tubes.—The Federal Porcelain Co., Cary, Ohio.

Polyphase Power Transformers—Bulletin 2040 gives cutaway views showing the construction of several of these high-tension transformer units.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Ball Bearings—A folder announces that a complete stock of Chapman ball bearings for power transmission on lineshafts, pillow blocks, and for loose pulleys, is carried by this company.—W. A. Jones Foundry & Machine Co., 4430 W. Roosevelt Rd., Chicago, Ill.

Fifty Years in Insulation—In a handsomely illustrated folder entitled, "Our Fiftieth Year," this company reviews briefly the progress of their concern in the manufacture of insulating equipment.—The R. Thomas & Sons Co., East Liverpool, Ohio.

Automatic Across the Line Starters—A new catalog describes the Sundh automatic a. c. starter of the across-the-line type with no-voltage release or low-voltage protection and also inverse time limit overload protection. Six different types of apparatus are described and listed.—Sundh Electric Co., Inc., Newark, N. J.

Fans and Blowers—Bulletin 1801 is a 72-page catalog of American "Sirocco" fans and blowers and gives capacities and specifications for the wide variety of units and different sizes.—American Blower Company, Detroit, Mich.

Commercial Roller Bearings—A catalog bearing the above title describes the construction of and lists Bond commercial roller bearings with or without split outer races for use in machinery of various kinds.—Bond Foundry & Machine Co., Manheim, Lancaster Co., Pa.

Spray Gun for Furnace Maintenance—Descriptive literature shows the construction and operation of the Quigley refractory gun for use in relining, patching or surfacing furnace walls. The refractory material is shot against the wall by air pressure. It is stated that this gun may also be used for rough whitewashing,

spraying paint or handling plastic mixtures such as stucco.—Quigley Furnace Specialties Co., 26 Cortlandt St., New York City.

Speed Transformer—Bulletin 105 describes the Poole Type H speed transformer, in which the shafts of the two herringbone gears are in a horizontal plane. Bulletin 106 describes the Type K speed transformer for increasing or decreasing speed, in which the shafts of the herringbone gears are in the vertical plane with the pinion shaft at the top.—The Poole Engineering & Machine Co., Baltimore, Md.

Double-Helical Gear Drives—Bulletin B discusses the types and methods of manufacture of double-helical gear drives with cut teeth, shows how they are made and gives a large number of illustrations of installations of Mesta speed reduction units and gear drives. Mesta flexible couplings are also illustrated.—Mesta Machine Co., P. O. Box 1124, Pittsburgh, Pa.

Direct-Current Automatic Starter—Bulletin 7107-C describes a new, direct-current automatic starter with time limit acceleration and the resistance mounted on the front of the panel. These starters are primarily intended for d. c. motors from ½ to 5 hp. Bulletin 7100-C describes the classes 7110, 7120 and 7130 direct-current automatic starters.—Industrial Controller Co., Milwaukee, Wis.

Jack-Type Disconnecting Switches—Circular 68455, Class 11, illustrates and describes the CR-1923, A-1 alternating-current, jack-type, disconnecting switches for single-phase, two-phase, or three- or four-wire, three-phase circuits. These switches provide convenient means for easily disconnecting motors and control equipment from the line for the purpose of inspecting or working on the equipment in safety.—General Electric Co., Schenectady, N. Y.

Automatic Starting Compensators—Bulletin 68456, Class 11, illustrates and describes the CR-7051-J1 automatic starting compensator for squirrel-cage induction motors, 25 to 60 cycle, two or three phase, with a maximum capacity of 15 hp. in the 25-cycle and 25 to 50 hp. in the 50- and 60-cycle types. This motor starter is for remote control of constant speed induction motors up to 600 volts.—General Electric Co., Schenectady, N. Y.

Materials-Handling Equipment—Bulletin 101 describes the Models F and G Barrett hand-lift trucks, and gives their construction and advantages. Bulletin 103 describes "Steeleg" platforms. Bulletin 300 describes the construction and operation and shows a large number of applications of the Barrett portable elevator for stacking material.—Barrett-Cravens Co., 1328 W. Monroe St., Chicago, Ill.

Safety Switches—Publication F-4648 entitled, "The A B C of Safety Switches," gives information on safety switches which is demanded by the specifications of the National Code and state and municipal ordinances. This booklet also deals with the many uses of safety switches and the principles of their operation. Among the points discussed are: A description of safety switches and their use; why switch parts burn out and the remedy; how to tell the proper type of switch for every job; the purpose and use of safety motor starters and how to tell the proper type for every job; what thermal cut-outs are and why they are used.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Water-Proof Paint for Wet Surfaces—A folder describes Mastertex which is a water-proof cement paint that can be applied directly to a wet, dripping wall such as the interior surface of a wet basement or the outside of rain-soaked stucco or concrete work. This paint may be obtained in several permanent colors.—The Master Builders Company, Cleveland, Ohio.

Charging Hoist for Foundry Cupolas—Bulletin 217 shows the construction and method of operation of the Roots charging hoist in foundries. This consists of a cage-operated monorail hoist with an extension arm carrying a bucket or magnet which is inserted into the cupola and the load dropped.—The P. H. & F. M. Roots Co., Connersville, Ind.

Squirrel-Cage Motor—Bulletin 100 describes the Linzee squirrel-cage, 40-deg. induction motor for two- and three-phase, constant-speed, continuous duty, which is provided with either ball or sleeve bearings. Special design, construction and operating features are given. This organization is successor to the Phoenix Electric Co.—The Linzee Electric Motor Co., Mansfield, Ohio.

Slack-Belt Idler—A folder describes the ball-bearing belt-slacker, which is a special belt idler that may be attached to any motor and is claimed to increase belt wrap without making high belt tension. This folder contains a useful table giving the approximate belt speeds in ft. per min. for two to fourteen-pole alternating-current motors with any diameter of pulley.—Harry M. Perry, 702 No. Main St., Los Angeles, Calif.

Coal Meter—Bailey Meter Co., 2015 E. Forty-sixth St., Cleveland, Ohio—Bulletin 221 describes the construction and operation and shows a number of installations of Bailey meters for coal and other granular materials. This meter consists of a spiral vane which is placed in the stoker feed pipe or other similar pipe and is rotated by the passing of the coal.

Conduit Fixtures—Crouse-Hinds Co., Syracuse, N. Y.—Bulletin 2062 describes and lists the Mogul series of conduit fixtures which meets the demand for units with an unusually long cover opening so as to avoid kinking heavy wire or cables when pulling or feeding through a conduit system.

Grounding Devices—Groundulet Co., 83 Park Place, Newark, N. J.—Circular 60 lists the various sizes and prices of different Groundit bushings, soldering studs and ground studs for switchboxes as well as the Groundulets for making quick and serviceable grounds in electrical distribution systems.

Remote Control for Circuit Breakers—Condit Electrical Mfg. Co., South Boston, Mass.—Bulletin 456 describes the electrically operated mechanism for automatic closing and reclosing of oil switches and circuit breakers by direct or alternating current. Bulletins 454 and 455 describe the Types D-13B and F-11 oil switches and circuit breakers for manual or electrical remote control in single unit construction and in truck-type units mechanically interlocked.

Brass Data Book—Bridgeport Data Book 16 devotes 48 pages largely to tabular material which gives dimensions, standards and other data on the copper and other alloy rods, tubes, bars and sheet made by this company. This is an interesting book in pocket size for anyone who must purchase material of this sort.—Bridgeport Brass Co., Bridgeport, Conn.

Portable Woodworking Machines—J. D. Wallace and Co., 134 South California Ave., Chicago, Ill.—Catalog 402 D contains a description of the complete line of Wallace portable machines for working wood. These consist of band saws, universal and plain circular saws, jointers, planers, lathes, all with direct motor drives, and a glue pot. All of these devices may be operated on an electric light or power circuit.

Non-Metallic Gears—General Electric Co., Schenectady, N. Y.—Circular 68711 entitled, "Textolite Gears," describes the construction and use of these gears which are made of Textolite, a special composition on a fiber base.

High-Frequency Oscillators—Leeds and Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.—Bulletin 984 describes the "Vreeland Oscillator" and other devices for producing high-frequency alternating current such as may be required in many of the measurements of inductance, capacity and resistance where it is desirable to determine these quantities at frequencies higher than the usual 60 cycles.

Line Hardware and Equipment—Line Material Co., South Milwaukee, Wis.—A bulletin entitled, "The Line," issued monthly, describes the use and application of a variety of line material equipment.

Steel Industrial Furniture—The Toledo Metal Furniture Co., Toledo, Ohio—Price list 625 gives quotations on steel equipment for office, factory, industrial cafeteria and other uses. This consists of tables and stands for offices, vaults, trucks, portable tool trays and trucks, PosturChair, stools and other metal furniture for industrial plants.

Load Indicators—A bulletin contains a complete description and many illustrations of the various types of Cory load and period indicators, manual controls and totalizing wattmeter-operated automatic control. This equipment provides a simple means of indicating at all times in the boiler room firing aisle, the exact electrical load being delivered by the station and insures a more even and economical firing of boilers.—Chas. Cory & Sons, Inc.—183-7 Varick St., New York.

Conduit Fixtures—Crouse-Hinds Co., Syracuse, N. Y.—Folder 13 and bulletin 2056 describes the line of connectors of the CG Series with rubber bushings or split-lead sleeves for connecting round flexible cord and cable, or armored or other round cable.